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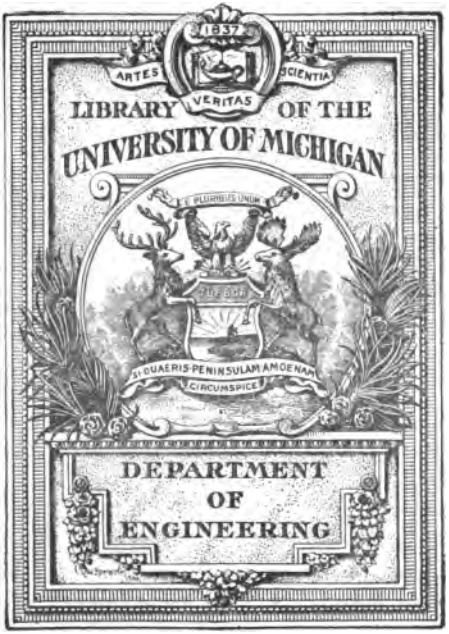


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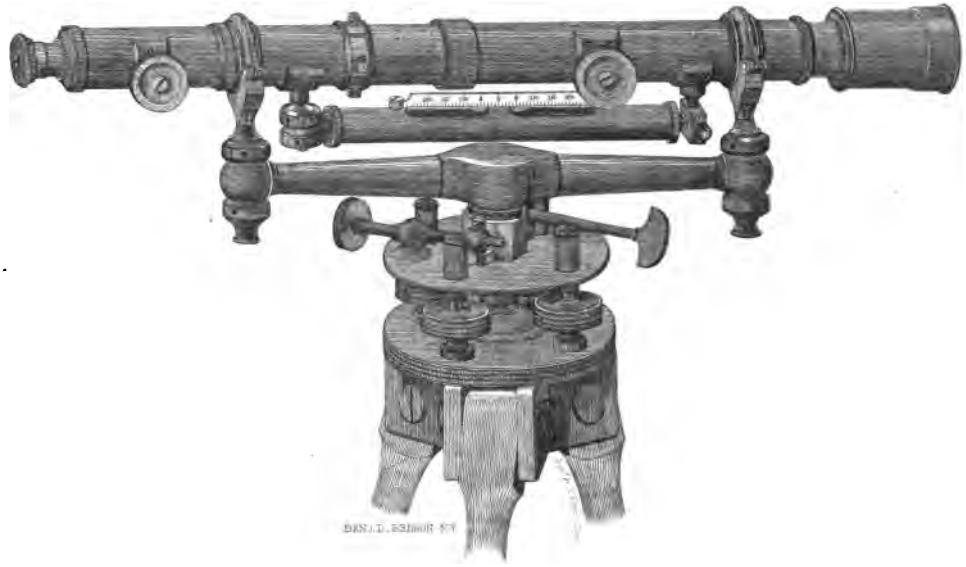

# LAND.

# TABLES.

DAVID MUNRO

# MANUAL

OF

# LAND SURVEYING,

WITH

# TABLES.

BY

DAVID MURRAY, A.M., PH.D.,

PROFESSOR OF MATHEMATICS IN RUTGERS COLLEGE.

NEW YORK:

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# PREFACE.

THE following little work has been prepared with the double object of furnishing a text-book in this branch of practical mathematics, and also a manual for the use of the surveyor. No attempt has been made to extend the work beyond the bounds indicated in the title. It will be found to be simply a treatise on Land Surveying accompanied with such practical directions and tables as the experience of American surveyors has shown to be most useful. The methods and instruments described are mainly those which prevail in American practice, and which have been found best adapted to the peculiar wants of this country. At the same time, in order to adapt the practice to the demand for more rigorous methods, and to give to the measurement of land the precision which its increase in value requires, greater prominence has been given to the use of the Transit in surveying, and improved modes of computing the areas introduced.

The admirable plates of field instruments with which the work is embellished, and which contribute so materially to the value of the book, have been kindly placed at the disposal of the author by the eminent manufacturers of Engineers' and Surveyors' Instruments, Messrs. W. & L. E. Gurley, of Troy, N. Y.

The author acknowledges his obligations to his associates, Professor George H. Cook and Professor E. A. Bowser for valuable suggestions and assistance in the preparation of the work, and also to the officers of the United States Coast Survey for many courtesies.

NEW BRUNSWICK, N. J., June, 1872.

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# MANUAL

OF

# LAND SURVEYING.

## INTRODUCTION.

**1.** LAND SURVEYING has for its object to determine the length of lines, the area and figure of parcels of land, and to represent the results in plots and maps.

**2.** The surface of the earth, considered in proportion to the extent of the measurements in surveying, being exceedingly irregular, we conceive a perfectly smooth and regular spherical surface to be formed by extending the surface of the quiet ocean beneath the uneven land. On this regular surface we conceive all points, lines, and surfaces to be projected by perpendiculars let fall. The points, lines, and areas considered in Land Surveying are not the real points, lines, and areas on the earth's surface, but their projections on this imaginary regular surface.

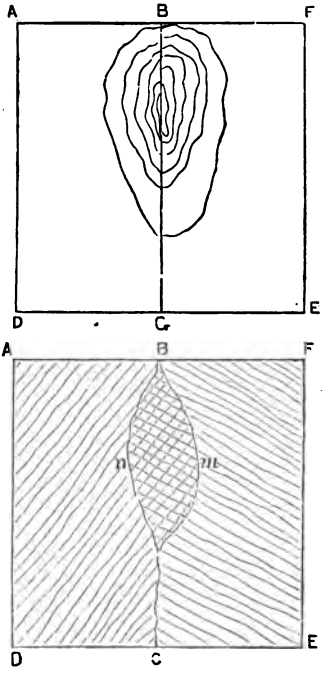



FIG. 1.

When a farm is surveyed and its contents computed, the boundaries which are measured are not the irregular and undulating lines on the surface of the ground, but the horizontal lines included between the same limits ; and the area obtained is not the actual ground-surface, but its horizontal equivalent. To obtain the real lines and real areas would, in most cases, be impossible, and the representation of them upon flat maps equally so. Thus, suppose two adjoining plots of ground, ABCD and CBFE (Fig. 1) having the lines AB, AF, EF, and BE all horizontal, but the line CB,

which divides the plots, to run over an elevation. If the surveyor, having obtained the true area, should attempt to map these two plots in their true position, side by side, in order to give the first its full area, he must curve its boundary-line to the right, giving the figure ABmCD, and in the second he must curve its boundary line to the left, giving the figure BnCEF. The two would overlap each other by the space CmBn.

Fortunately, in the transfer and partition of land, it has always been considered equitable to regard the loss of area in uneven land as compensated by the greater value of level land. And in practical agriculture it is plain that no more stems of grain can grow upon a slope than could grow on the corresponding horizontal surface.

**3.** The surface on which surveys are, therefore, actually to be made, is a spherical surface. But in **Plane Surveying** the extent of surface is so small that the lines may be regarded as straight lines, and the areas as planes. In **Geodetical Surveying** the operations are so extensive and so precise as to require the curvature of the earth to be taken into account.

In a triangle having sides each one mile in length, the difference in area, whether it be regarded as a plane triangle, or a triangle having sides curved with the earth's surface, is only $2\frac{3}{4}$ square feet. Each of the angles of such a spherical triangle would only exceed that of the plane triangle by $0''.0019$. And the angles of a spherical triangle, whose area is 75.5 square miles, would only exceed those of the plane triangle, having sides of the same length, by $1''$.

Hence it is safe to assume that the divisions of land included in the operations of an ordinary land-survey may be treated without appreciable error as plane figures.

**4.** There are two kinds of quantities to be measured in Land Surveying, **lines** and **angles**. From the direct measurement of certain lines and angles, in a figure, we are able to obtain, by computation, other lines and angles, and their included areas. It will be the object of this manual to explain how to measure these lines and angles, and how to compute the required areas. The instruments which are required in the operations will be described, and their uses explained.

## INSTRUMENTS.

**5.** Besides the field instruments employed in Land Surveying, a description of which is given in their appropriate chapters, there are a number of smaller instruments, which are used in making diagrams and plots of the executed work. A brief enumeration of them is here given.

**Drawing-Board.**—This is a plane, smooth board of dry pine, made perfectly square at the corners. The ends should have strips tongued and

grooved into them, with the grain running in the opposite direction, to prevent warping. The board should be about 24 by 30 inches.

**T-Square.**—This consists of two pieces of wood fastened firmly together, at right angles to each other. The long arm is not less than 24 inches long, and the short one about 10 inches. The short arm is thicker than the other, giving a shoulder on one or both sides. This instrument, laid on the drawing-board, with the shoulder against the edge, furnishes an easy method of drawing lines parallel and perpendicular to each other.

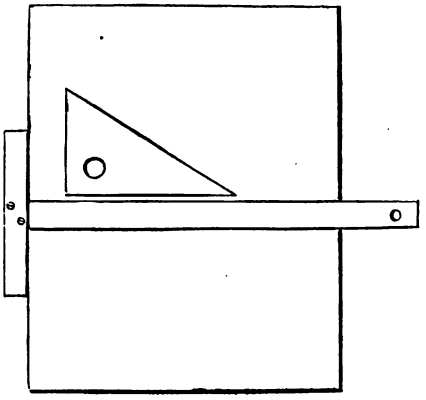


FIG. 2.

**Triangle.**—A thin triangle of wood, made right-angled at one corner and the other angles 30° and 60°, is useful in drawing parallel lines.

**Scales.**—The distances measured upon the ground are to be laid down

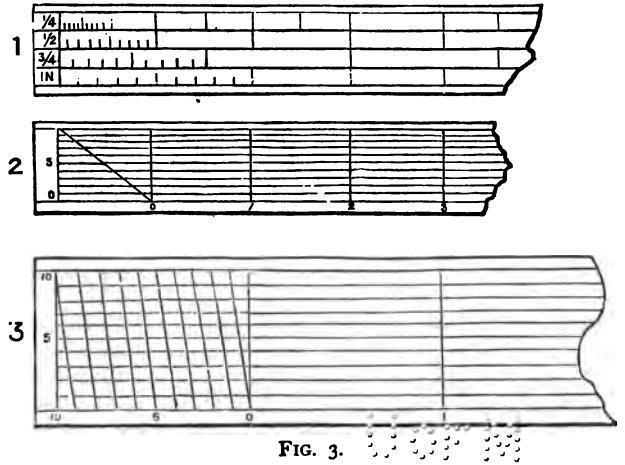



FIG. 3.

on paper on a reduced scale. Thus, we represent the chain by an inch, or

by half-an-inch. The instrument with which these reduced measurements are laid off is called a **scale.** Fig. 3 represents three different varieties of scales. The simplest one consists of a small unit, as one inch, laid off on a wood or ivory bar about 6 inches long. The unit at the left end is divided into smaller equal parts, usually 10 or 12. Such a scale measures inches and tenths, or inches and lines. If an inch is taken to represent one chain, then each tenth would represent ten links.

The second is called a **Diagonal Scale.** The unit at the left end has a line diagonally across the ten equal spaces into which the scale is divided by parallel lines. Since the diagonal advances one unit in crossing the entire ten spaces, it must advance one-tenth in crossing one space, two-tenths in crossing two spaces, etc. Hence, if we want a distance of seven spaces, for example, we must measure the distance the diagonal has advanced when it has reached the line marked 7. Thus, a distance of 1.7 would extend from the point where the diagonal cuts the seventh parallel to the point where the cross-line marked 1 cuts the same parallel.

When we want a scale which will measure to hundredths, it can best be arranged as shown in the third part of the figure. The scale is divided longitudinally into ten spaces. The upper and lower lines of the left unit are divided each into ten equal parts. Diagonals are then drawn from 0 in the lower line, to 1 in the upper; from 1 in the lower, to 2 in the upper, etc. It is evident that one of these diagonals in crossing one space advances one-tenth of one-tenth of the unit; and hence the scale can be used for measuring to hundredths.

6. **Dividers.**—This instrument is used for laying off on paper the distances measured. Two forms are shown in the figure. The one has shifting legs, to which may be fitted, when wanted, a pencil-point, a pen-point, or a needle-point. When very large circles are to be drawn, a beam compass is used. It consists of a beam of wood or metal to which are attached two points; one of which, carrying a pencil or pen, may be clamped at any required distance.

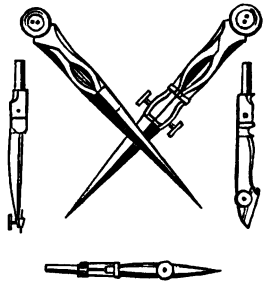


FIG. 4.

7. **Drawing-Pen.**—A drawing-pen consists of two blades of steel commanded by a small screw, by which their distance apart can be regulated to produce any thickness of line. It may be used without blotting to draw lines along a ruler. In using pens, **India-ink** should be used instead of common ink. It does not corrode the pen, and gives a peculiarly smooth and brilliant line.

**8. Protractor.**—It consists generally of a semicircle divided into degrees, and is used for laying off a given angle from any point of a given line. Lay the protractor so that the straight edge coincides with the given line, and the centre point with the given point. The angle may then be found on the divided circle, and a straight line drawn through the centre, and this point will make the angle required.

A protractor may be made by marking off the degrees on three sides of the rectangle composing any scale.

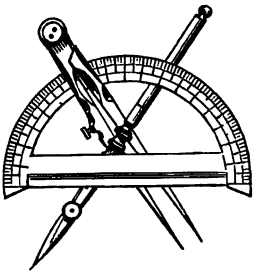


FIG. 5.

# CHAPTER I.

## PLANE TRIGONOMETRY.

**9.** A TRIANGLE has three sides and three angles, which are called its parts. These parts are so related to each other that, if three of them are given—one being a side—the remainder may be found. Trigonometry is the science of triangles; and plane trigonometry treats of triangles in a plane. Only so much of plane trigonometry is here given as is essential to the subject of land surveying.

**10.** The angle between two lines is measured by the arc of a circle included between its sides. Thus BC, in Fig. 6, is the measure of the angle A.

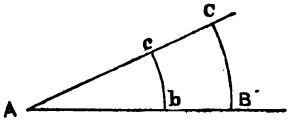



FIG. 6.

For the purpose of expressing this measurement, we conceive the circumference of a circle to be divided into 360 equal parts, called degrees, and each degree into 60 equal parts, called minutes, and each minute into 60 equal parts, called seconds. They are expressed by the characters ° ′ ″. The magnitude of the angle A is thus expressed by the number of degrees, minutes, and seconds contained in the arc BC.

It is plain that the arc *bc* contains the same number of degrees, minutes, and seconds as the arc BC; hence, either arc may be taken as the measure of the angle A, and the measurement of angles is independent of the magnitude of the radius of the measuring arc.

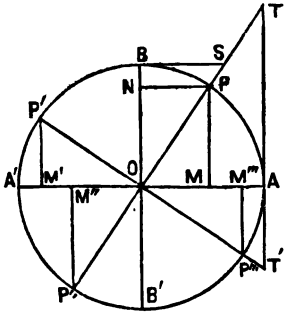



FIG. 7.

**11.** A **quadrant** is the fourth part of the circumference of a circle. The **complement** of an arc is what remains after subtracting the arc from a quadrant. The **supplement** of an arc is what remains after subtracting it from half the circumference. Since a quadrant is 90°, the complement of an arc, or the angle which it measures, will be obtained by subtracting the number of degrees from 90°. And the supplement will be obtained by subtracting from 180°. Thus, let an arc contain

70° 30′, its complement will be 19° 30′, and its supplement 109° 30′. In Fig. 7 AB is a quadrant, BP is the complement of the arc AP, and PA′ is its supplement. AP′ being an arc, minus BP′ is its complement, and P′A′ its supplement.

**12.** The **sine** of an arc is a perpendicular let fall from one end of an arc upon a diameter drawn through the other end. Thus, PM is the sine of the arc AP, BO the sine of AB, P′M′ the sine of ABP′, etc.

The **tangent** of an arc is a line drawn touching one extremity of an arc, and terminated by a line drawn through the centre and the other extremity. Thus, AT is the tangent of the arc AP, AT′ the tangent of ABP′, AT the tangent of ABA′P″, etc.

The **secant** of an arc is a line drawn from the centre through one extremity of the arc, and terminated by a tangent drawn through the other extremity. Thus, OT is the secant of the arc AP, OT′ the secant of ABP′, etc.

The sine of the complement of an arc is called its **cosine.** In Fig. 7, PN, which is the sine of BP, is called the cosine of AP. It is evident that in all cases the cosine is equal to the distance from the centre to the foot of the sine; thus NP, the cosine of AP, is equal to OM.

The **cotangent** and **cosecant,** in like manner, are the tangent and secant of the complement of an arc. BS and OS, Fig. 7, are the tangent and secant of BP, and consequently the cotangent and cosecant of AP.

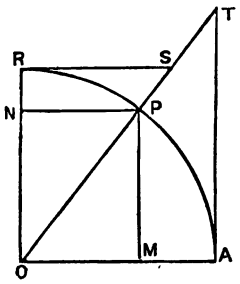


FIG. 8.

**13.** The mutual relations of the above lines, which are called the functions of an arc, and of the radius of the circle, are expressed in the following proportions:

In Fig. 8 let the arc AP be represented by $a$, and the radius OA by R, then from the similar triangles OPM, OTA, and ORS, we have

$$\text{OM} : \text{PM} :: \text{OA} : \text{AT}$$

$$\cos a : \sin a :: \text{R} : \tan a = \frac{\text{R} \sin a}{\cos a}. \quad (1.)$$

$$\text{OM} : \text{OP} :: \text{OA} : \text{OT}$$

$$\cos a : \text{R} :: \text{R} : \sec a = \frac{\text{R}^2}{\cos a}. \quad (2.)$$

$$PM : OM :: OR : RS$$

$$\sin a : \cos a :: R : \cot a = \frac{R \cos a}{\sin a}. \quad (3.)$$

$$PM : OP :: OR : OS$$

$$\sin a : R :: R : \operatorname{cosec} a = \frac{R^2}{\sin a}. \quad (4.)$$

$$AT : OA :: OR : RS$$

$$\tan a : R :: R : \cot a = \frac{R^2}{\tan a}. \quad (5.)$$

Also, from the right-angled triangle OPM we have

$$PM^2 + OM^2 = OP^2$$

$$\sin^2 a + \cos^2 a = R^2 \quad (6.)$$

$$\sin a = \sqrt{R^2 - \cos^2 a}$$

$$\cos a = \sqrt{R^2 - \sin^2 a}$$

**14.** The **algebraic signs** of the functions of an arc are determined thus:

All lines measured upward from the horizontal diameter are positive, all measured downward are negative.

All lines measured from the vertical diameter to the right are positive, and all measured to the left are negative.

In Fig. 7, PM, the sine of AP, is positive; P'M', the sine of AP', is positive. PN, the cosine of AP, is positive, and OM', the cosine of AP', is negative. From an inspection of this figure it will be apparent that the sines are positive for arcs in the first and second quadrant, and negative for the third and fourth. Also that the cosines are positive in the first and fourth quadrants, and negative in the second and third.

The signs of the tangents, secants, cotangents and cosecants may be determined from the equations in article 13. Since $\tan a = \frac{R \sin a}{\cos a}$ and $\cot a = \frac{R \cos a}{\sin a}$, it is evident that both tangent and cotangent will be positive when the sine and cosine have the same signs, and negative when their signs are unlike. From equations (2) and (4) it is also evident that the secant will have the same sign as the cosine, and the cosecant as the sine. These results may be summed up in the following table:

| | First Quad. | Second Quad. | Third Quad. | Fourth Quad. |
|---|---|---|---|---|
| Sine..... | + | + | − | − |
| Cosine..... | + | − | − | + |
| Tangent..... | + | − | + | − |
| Cotangent..... | + | − | + | − |
| Secant..... | + | − | − | + |
| Cosecant..... | + | + | − | − |

**15. Natural sines, tangents, etc.,** are so named when the radius of the circle is equal to one. In Fig. 7, if the radius of the circle were one foot or one yard, the sine PM would then be the natural sine, AT would be the natural tangent, etc.

A table of natural sines, tangents, etc., gives the values of these functions for all arcs from 0° to 90°, usually at intervals of one minute. By interpolation the value for intermediate seconds may be obtained. In such a table the sines would begin with a value of zero for an arc of 0°, and increase to a value equal to the radius or a unit for 90°. The cosines would begin with a value of a unit for 0°, and decrease to a value of zero for 90°.

Between the same limits the tangents would vary between zero and infinity; the secants between radius and infinity; the cotangents between infinity and zero, and the cosecants between infinity and radius.

**16.** In Fig. 7 we see that PM is the sine of the arc AP and also of the arc A′P, and P′M′ is the sine of both the arcs AP′ and A′P′. And, in general, the sine of an arc is always equal to the sine of its supplement. The sine of 100° is the same as the sine of 80°.

Similarly we see that the cosine of an arc is equal to the cosine of its supplement, but is measured in an opposite direction, and therefore has an opposite sign. The tangent of an arc is equal to minus the tangent of its supplement, and the cotangent equal to minus the cotangent of its supplement.

A table of sines, tangents, etc., is only required, therefore, to extend to 90°. For arcs greater than 90° the sines, tangents, etc., may be obtained by employing their supplements.

Thus, $\sin 144° 36' = \sin 35° 24' = 0.57928$
$\cos 144° 36' = -\cos 35° 24' = -0.81513$

**17.** A table of **logarithmic sines, tangents, etc.,** gives the logarithms of the sines, tangents, etc., of all arcs from 0° to 90°. By the use of these

the computations may be much abbreviated, using additions instead of multiplications, and subtractions instead of divisions.

The natural sines and cosines being always, and the other functions sometimes, less than one, their logarithms would in these cases have negative characteristics. To avoid this inconvenience in computation, all the functions are multiplied by 10 billions, or, in other words, their logarithms are increased by 10. This is the same as taking the functions in a circle whose radius is 10 billions.

The method of finding the sine, tangent, etc., for a given arc, and also the reverse method of finding the arc for a given sine, tangent, etc., both from the table of natural sines and from the table of logarithmic sines, will be found in the explanations prefixed to the tables. To these the student is referred.

**18.** The principles involved in the solution of plane triangles may be stated in six theorems. Throughout we shall use the large letters A, B, C, to represent the angles, and the small letters $a$, $b$, $c$, to represent their corresponding opposite sides.

**Theorem I.** In any right-angled triangle, radius is to the hypothenuse as the sine of either acute angle is to the side opposite, or as the cosine of the angle is to the side adjacent.

Let ABC be a triangle right-angled at A. With a radius equal to R describe the arc DE around the angle C, and draw the sine DF. CF will be the cosine.

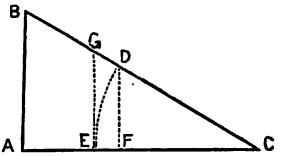


FIG. 9.

By similar triangles we have

$$\text{CD} : \text{CB} :: \text{DF} : \text{AB}$$

that is,
$$\text{R} : a :: \sin C : c$$

also,
$$\text{CD} : \text{CB} :: \text{CF} : \text{CA}$$
$$\text{R} : a :: \cos \text{C} : b$$

These proportions may be expressed in two equations:

$$\text{R} \times c = a \times \sin \text{C} \quad (7.)$$
$$\text{R} \times b = a \times \cos \text{C} \quad (8.)$$

**19. Theorem II.** In any right-angled plane triangle, radius is to either side as the tangent of the adjacent acute angle is to the side opposite, or as the secant of the same angle is to the hypothenuse.

In Fig. 9, draw the line EG a tangent to the arc DE, then will CG be the secant.

By similar triangles we have

$$CE : CA :: EG : AB$$

that is,
$$R : b :: \tan C : c$$

also,
$$CE : CA :: CG : CB$$
$$R : b :: \sec C : a$$

By changing these proportions into equations, we have

$$R \times c = b \times \tan C \quad (9.)$$
$$R \times a = b \times \sec C \quad (10.)$$

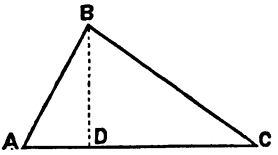



FIG. 10.

**20. Theorem III.** In any plane triangle, the sides are proportional to the sines of the opposite angles.

Let ABC be any triangle. Draw BD perpendicular to one side; it divides the triangle into two right-angled triangles.

In the triangles ABD and BDC we have from equation (7)

$$R \times BD = AB \times \sin A = c \times \sin A$$
$$R \times BD = BC \times \sin C = a \times \sin C$$
$$a \times \sin C = c \times \sin A$$
$$a : c :: \sin A : \sin C$$

or,
$$\frac{a}{c} = \frac{\sin A}{\sin C} \quad (11.)$$

**21. Theorem IV.** In any plane triangle the sum of two sides is to their difference as the tangent of half the sum of the angles opposite is to the tangent of half their difference.

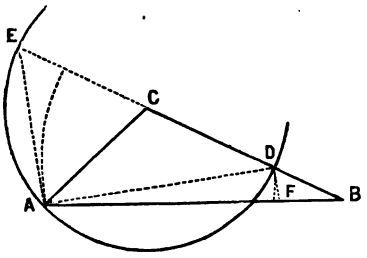



FIG. 11.

Let ABC be a triangle. With C as a centre and CA, the shorter of two sides, as a radius, describe a circle, cutting CB in D, and BC extended in E. Join AE, and draw DF parallel to AE.

$$BE = BC + CA = a + b$$
$$BD = BC - CA = a - b$$

also,
$$ACE = CAB + CBA = A + B$$

But ADE being an angle at the circumference, while ACE is at the centre, both intercepting the same arc,

$$\text{ADE} = \tfrac{1}{2}\text{ACE} = \tfrac{1}{2}(\text{A} + \text{B})$$

By subtracting half the sum of two quantities from the greater, we obtain half the difference. Hence,

$$\text{DAF} = \text{CAB} - \text{CAD} = \text{A} - \tfrac{1}{2}(\text{A} + \text{B}) = \tfrac{1}{2}(\text{A} - \text{B})$$

The angle EAD, being inscribed in a semicircle, is a right angle, and AE and DF are perpendicular to AD. If, with AD as radius, arcs be described, measuring the angles ADE and DAF, AE will be the tangent of the first and DF of the last.

Then, by similar triangles,

$$\text{BE} : \text{BD} :: \text{AE} : \text{DF}$$

that is, $$a + b : a - b :: \tan \tfrac{1}{2}(\text{A} + \text{B}) : \tan \tfrac{1}{2}(\text{A} - \text{B})$$

or,
$$\frac{a + b}{a - b} = \frac{\tan \tfrac{1}{2}(\text{A} + \text{B})}{\tan \tfrac{1}{2}(\text{A} - \text{B})} \quad (12.)$$

**22. Theorem V.** In any triangle, if a perpendicular be let fall from either angle upon the opposite side, the sum of the segments is to the sum of the sides as the difference of the sides is to the difference of the segments.

Let ACB, Fig. 12, be a triangle, and CD a perpendicular let fall upon AB. With C as a centre, and a radius AC, describe a circle cutting BC in G and BC extended in E.

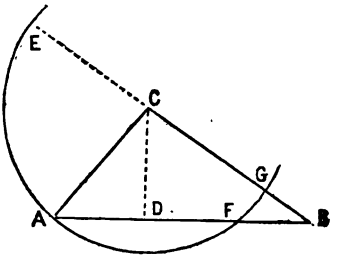



FIG. 12

then,
$$\begin{aligned} \text{BE} &= \text{BC} + \text{CA} = a + b \\ \text{BG} &= \text{BC} - \text{CA} = a - b \\ \text{BA} &= \text{BD} + \text{AD} = m + n \\ \text{BF} &= \text{BD} - \text{AD} = m - n \end{aligned}$$

From the relation of secants to their external segments we have

$$\text{BA} : \text{BE} :: \text{BG} : \text{BF}$$
$$m + n : a + b :: a - b : m - n$$

or,
$$(m + n)(m - n) = (a + b)(a - b). \quad (13.)$$

**23. Theorem VI.** To determine the angles of a triangle when the

three sides are given, we have the following formulæ, for proof of which we refer to works on analytical trigonometry:

$$\left.\begin{aligned} \sin \tfrac{1}{2}A &= R\sqrt{\frac{(s-b)(s-c)}{bc}} \\ \sin \tfrac{1}{2}B &= R\sqrt{\frac{(s-a)(s-c)}{ac}} \\ \sin \tfrac{1}{2}C &= R\sqrt{\frac{(s-a)(s-b)}{bc}} \end{aligned}\right\} \quad (14.)$$

in which $s = \frac{1}{2}(a + b + c)$.

From the above theorems, with the aid of ordinary algebra and geometry, all problems arising under triangles may be solved.

## 24. RIGHT-ANGLED TRIANGLES.

I. Given the hypothenuse $a$, and one of the acute angles, to find the two sides $b$ and $c$, and the remaining angle.

1. The angle may be found from the equation

$$B + C = 90°.$$

2. To find $b$ and $c$, we have equations (7) and (8)

$$R \times b = a \times \sin B\,; \quad R \times c = a \times \cos B.$$

II. Given one of the acute angles, as B, and one of the legs, as $c$, to find the other angle and leg, and the hypothenuse.

1. Find the remaining angle from the equation

$$B + C = 90°.$$

2. Find the other leg from equation (9)

$$R \times b = c \times \tan B.$$

3. Find the hypothenuse from equation (10)

$$R \times a = c \times \sec B.$$

III. Given the hypothenuse and one leg, as $b$, to find the angles and other leg.

1. Find B from equation (7)

$$R \times b = a \times \sin B.$$

2. Find C from the equation

$$B + C = 90°.$$

3. Find $c$ from the equation

$$R \times c = a \times \cos B.$$

IV. Given the two legs, to find the angles B and C, and the hypothenuse.

1. Find B and C from equations

$$R \times b = c \times \tan B, \text{ and } R \times c = b \times \tan C$$

From which

$$\tan B = \frac{R \times b}{c}, \text{ and } \tan C = \frac{R \times c}{b}$$

2. Find $a$ from the equation

$$R \times b = a \sin B, \quad \therefore a = \frac{R \times b}{\sin B}$$

Or from equation

$$a^2 = b^2 + c^2$$

EXAMPLES.

1. In a right-angled triangle, given the angle B 30° 45′, and the hypothenuse 100 yards. Required the remaining parts.

$$C = 90° - B = 59° 15'$$

| $R \times b = a \times \sin B$ | | $R \times c = a \times \cos B$ | |
|---|---|---|---|
| Log $a$ = | 2.000000 | Log $a$ = | 2.000000 |
| + Log sin B = | 9.708670 | + Log cos B = | 9.934199 |
| − Log R = | 10.000000 | − Log R = | 10.000000 |
| Log $b$ 51.13 = | 1.708670 | Log $c$ 85.94 | 1.934199 |

Or, by natural sines and cosines

$$b = 100 \times .51129 = 51.129 \textit{ Ans.}$$
$$c = 100 \times .85941 = 85.941 \textit{ Ans.}$$

2. In a right-angled triangle, given the two legs 130 and 150 yards, to find the remaining parts.

*Ans.* Hypothenuse 198.49, angles 49° 5′ 8″ and 40° 54′ 52″.

3. In a right-angled triangle, given one acute angle 48° 12′, and the side opposite to it 166 feet, required the remaining parts.

*Ans.* Hypothenuse 222.67, side 148.42, angle 41° 48′.

4. In a right-angled triangle, given the hypothenuse 200 yards, and one leg 100 yards, to find the remaining parts.

*Ans.* Side 173.20, angles 60° and 30°.

## 25. OBLIQUE-ANGLED TRIANGLES.

V. Given two angles and one side, to find the remaining parts.

Let A, B, and $a$ be given.

1. Find the third angle from the equation

$$A + B + C = 180°$$

2. Find the remaining sides from equation (11)

$$\frac{a}{c} = \frac{\sin A}{\sin C},$$

$$c = \frac{a \sin C}{\sin A} \text{ and } b = \frac{a \sin B}{\sin A}$$

EXAMPLE.—Let two angles of a triangle be A 41° 38′, and B 68° 12′, respectively, and the side included between them be $c$ 150 yards.

$$C = 180° - (A + B) = 70° 10'$$

$$a = \frac{c \sin A}{\sin C} \text{ and } b = \frac{c \sin B}{\sin C}$$

| | |
|---|---|
| Log $c$ = 2.176091 | Log $c$ = 2.176091 |
| + Log sin A = 9.822404 | + Log sin B = 9.967775 |
| − Log sin C = 9.973444 | − Log sin C = 9.973444 |
| Log $a$ = 2.025051 | Log $b$ = 2.170422 |
| $a$ = 105.93+ *Ans.* | $b$ = 148.05+ *Ans.* |

VI. Given two sides and the angle opposite to one of them, to find the remaining parts.

Let $a$, $b$, and A be given.

1. Find the angle B by equation (11)

$$\frac{a}{b} = \frac{\sin A}{\sin B} \quad \therefore \sin B = \frac{b \sin A}{a}$$

2. Find the angle $c$ from the equation

$$A + B + C = 180°$$

3. Find $c$ from equation (11)

$$c = \frac{a \sin C}{\sin A}$$

Since the sine of an angle and the sine of its supplement are the same, in finding the angle B, from the table, either the acute angle or its supplement will be a proper result. There must, therefore, in this case, be

two triangles, both answering to the given conditions. Thus ABC, Fig. 13, is a triangle whose angle is A, and whose sides are $a$ and $b$. The angle B is an acute angle.

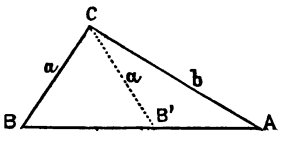



FIG. 13.

If, with the point C as a centre and the side $a$ as a radius, we describe an arc, cutting the side AB in B', it is plain the triangle AB'C has the same angle A, and the same two given sides $a$ and $b$. Either triangle is, therefore, a proper solution of the problem. It is further evident that the angle CB'A = 180° − B, and, therefore,

$$\sin CB'A = \sin B$$

When A is acute, and the side $a$ is greater than $b$, or when A is obtuse, it is evident there can be but one triangle, and then but one solution.

EXAMPLE.—Given A 44° 27′, and the side $a$ 160 yards, and $b$ 200 yards, required the remaining parts.

$$\sin B = \frac{b \sin A}{a}$$

$$\begin{aligned} \log b &= 2.301030 \\ + \log \sin A &= 9.845276 \\ - \log a &= 2.204120 \\ \log \sin B &= 9.942186 \end{aligned}$$

$$\therefore B = 61° 5' 14'' \text{ or } B' 118° 54' 46''$$

$$C = 180° - (A + B) = 74° 27' 46'' \text{ or } C' = 16° 38' 14''$$

$$c = \frac{a \sin C}{\sin A}$$

| | | | |
|---|---|---|---|
| $\log a$ | $= 2.204120$ | $\log a$ | $= 2.204120$ |
| $+ \log \sin C$ | $= 9.983832$ | $+ \log \sin C'$ | $= 9.456839$ |
| $- \log \sin A$ | $= 9.845276$ | $- \log \sin A$ | $= 9.845276$ |
| $\log c$ | $= 2.342676$ | $\log c'$ | $= 1.815683$ |
| $c$ | $= 220.128$ *Ans.* | $c'$ | $= 65.416$ *Ans.* |

VII. Given two sides and the included angle, to find the remaining parts.

Let A, $b$, and $c$ be the parts given.

1. Find the angles B and C by equation (12)

$$\frac{b + c}{b - c} = \frac{\tan \tfrac{1}{2}(B + C)}{\tan \tfrac{1}{2}(B - C)}$$

$$(B + C) = 180° - A.$$

$$\tan \tfrac{1}{2}(B - C) = \frac{(b - c) \tan \tfrac{1}{2}(B + C)}{b + c}$$

$$B = \tfrac{1}{2}(B + C) + \tfrac{1}{2}(B - C)$$
$$C = \tfrac{1}{2}(B + C) - \tfrac{1}{2}(B - C)$$

2. Find $a$ by equation (11)

$$\frac{a}{b} = \frac{\sin A}{\sin B} \quad \therefore a = \frac{b \sin A}{\sin B}$$

EXAMPLE.—Given in a triangle A 54° 20′, $b$ 180 yards, and $c$ 150 yards. Required B, C, and $a$.

$$B + C = 180° - A = 125° 40'$$
$$\tfrac{1}{2}(B + C) = 62° 50'$$
$$b + c = 330 \text{ and } b - c = 30$$
$$\log (b - c) = 1.477121$$
$$+ \log \tan \tfrac{1}{2}(B + C) = 10.289718$$
$$- \log (b + c) = \underline{2.518514}$$
$$\log \tan \tfrac{1}{2}(B - C) = 9.248325$$
$$C\ \tfrac{1}{2}(B - c) = 10° 2' 43''$$
$$B = 72° 52' 43'' \qquad C = 52° 47' 17''.$$

$$\log b = 2.255273$$
$$+ \log \sin A = 9.909782$$
$$- \log \sin B = \underline{9.980314}$$
$$\log a = 2.184741$$
$$\therefore a = 153.017$$

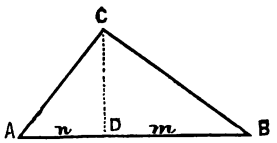



FIG. 14.

VIII. Given the three sides, to find the angles.

*First Method.*

1. Find the segments $m$ and $n$ by equation (13)

$$(m + n)(m - n) = (a + b)(a - b)$$

$$m - n = \frac{(a + b)(a - b)}{m + n}$$

$$m = \tfrac{1}{2}(m + n) + \tfrac{1}{2}(m - n)$$
$$n = \tfrac{1}{2}(m + n) - \tfrac{1}{2}(m - n)$$

2. Find A and B by equation (8)

$$R \times n = b \cos A \quad \therefore \cos A = \frac{R \times n}{b}$$

$$R \times m = a \cos B \quad \therefore \cos B = \frac{R \times m}{a}$$

*Second Method.*

Find each of the angles by the equations (14)

$$\sin \tfrac{1}{2}A = R\sqrt{\frac{(s-b)(s-c)}{bc}}, \text{ etc.}$$

When all the angles are thus found, their sum should make 180°. When two have been thus found, the third may be obtained by subtracting their sum from 180°.

EXAMPLE.—Given the three sides of a triangle, $a$, $b$, $c$, 100, 150, and 200 yards, to find the angles.

$$2s = a + b + c = 450 \therefore s = 225$$

$$s - a = 125,\ s - b = 75,\ s - c = 25$$

To find A,

$$\begin{aligned} \log R^2 &= 20.000000 \\ + \log (s-b) &= 1.875061 \\ + \log (s-c) &= 1.397940 \\ - \log b &= 2.176091 \\ - \log c &= 2.301030 \\ & \overline{18.795880} \\ \sin \tfrac{1}{2}A &= 9.397940 \\ \tfrac{1}{2}A &= 14^\circ\ 28'\ 39'' \\ A &= 28^\circ\ 57'\ 18'' \end{aligned}$$

To find B,

$$\begin{aligned} \log R^2 &= 20.000000 \\ + \log (s-a) &= 2.096910 \\ + \log (s-c) &= 1.397940 \\ - \log a &= 2.000000 \\ - \log c &= 2.301030 \\ & \overline{19.193820} \\ \sin \tfrac{1}{2}B &= 9.596910 \\ \tfrac{1}{2}B &= 23^\circ\ 17'\ 1'' \\ B &= 46^\circ\ 34'\ 2'' \end{aligned}$$

To find C,

$$\begin{aligned} \log R^2 &= 20.000000 \\ + \log (s-a) &= 2.096910 \\ + \log (s-b) &= 1.875061 \\ - \log a &= 2.000000 \\ - \log b &= 2.176091 \\ & \overline{19.795880} \end{aligned}$$

$$\sin \tfrac{1}{2} C = 9.897940$$
$$\tfrac{1}{2} C = 52^\circ\ 14'\ 20''$$
$$C = 104^\circ\ 28'\ 40''$$

Sum of the angles,

$$A = 28^\circ\ 57'\ 18''$$
$$B = 46^\circ\ 34'\ 2''$$
$$C = 104^\circ\ 28'\ 40''$$
$$\text{Sum} = 180^\circ$$

## MISCELLANEOUS EXAMPLES.

1. In the triangle ABC, given AB 153 yards, AC 137 yards, and the angle A 40° 33′ 12″; required the remaining parts.

*Ans.* B 61° 13′ 47″, C 78° 13′ 1″, BC 101.62.

2. In the triangle ABC, given AB 70 miles, AC 60 miles, and BC 50 miles: required the angle A. *Ans.* 44° 24′ 56″.

3. In the triangle ABC, given AB 500 yards, the angle A 105° 30′, and the angle B 47°; required AC. *Ans.* 791.9.

4. In a right-angled triangle ABC, given B 90°, A 30°, and AB 200 feet; required BC. *Ans.* 115.4.

5. In the right-angled triangle ABC, given the hypothenuse AC 480, and the angle A 53° 8′; required the two legs.

*Ans.* BC 384.0, AB 287.9.

6. In the triangle ABC, given A 44° 13′ 24″, B 55° 59′ 58″, and AC 368; required the remaining parts.

*Ans.* C 79° 46′ 38″, AB 436.84, BC 309.60.

# CHAPTER II.

## MEASUREMENT OF LINES.

**26.** THE unit of length commonly employed in Land Surveying is the **chain**, called, after its inventor, **Gunter's chain**. It is 66 feet, or 4 rods, in length. It was so chosen because 10 square chains were exactly equal to one acre. The chain is divided into 100 parts, called links; hence, in recording distances measured with the chain, the number of links may be written as decimals of a chain, and so used in computations. The link is 7.92 inches, or nearly two-thirds of a foot.

Other units of length are often used. In measuring small plots of ground, as city-lots, or streets and roads, the dimensions are nearly always expressed in **feet** and inches. The **rod** and **yard** are also used. All of these units are easily converted into each other. In the United States Coast Survey it has been found convenient to employ the **metre**, the French unit of measure. It is equal to 3.280899 feet, or 39.370799 inches.

**27.** The Gunter's chain is made of iron or steel wire, joined together in links by small rings. At the ends handles of brass are attached, and swivels are inserted at the middle and quarter points to prevent kinking. Brass tags are inserted at intervals of ten links to facilitate counting; those at ten links from each end having one point, those at twenty, two, those at thirty, three, those at forty, four, and that at the middle being rounded.

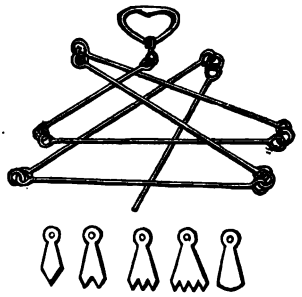


FIG. 15.

Chains should also be made so that they may be taken apart at the middle and quarter points, and used in sections for chaining on steep ground.

The best chains are now made of steel wire, which, being stronger than iron, permits the chain to be made much lighter.

A chain measuring 100 feet is used in preference to the Gunter's chain for many kinds of work. It is divided into 100 links, each being, there-

fore, one foot long. It is used in the engineering work of railroads, canals, sewers, etc. Being longer, work with it is more rapid and liable to fewer errors. The formulas for railroad curves, and for embankments and excavations, are all constructed on the basis of a hundred feet chain.

**28.** The chain is liable to changes of length, arising from stretching the rings, or bending the links. A change of temperature from 32° to 100° Far.—a change to which the chain is often exposed—makes a difference of about one-third of an inch in the length of a Gunter's chain. The surveyor requires, therefore, the means of **testing** the length of his chain. He should have a standard accurately laid off on some permanent, smooth surface, such as a flag-walk, a curb-stone, or the stone water-table of a building. On frequent occasions the chain should be compared with the standard, and, if found inaccurate, be corrected.

**29.** If a line has been measured by an inaccurate chain, the true distance may be determined by the following proportion:

66 feet : the length of the inaccurate chain in feet ::
the measured distance : the correct distance.

Or, 66 feet : the error of the chain in feet ::
the measured distance : the correction required.

Or, the length of the standard given by the incorrect chain, in links :
100 links :: the length of the measured line : the true length.

If the area of a plot of ground has been computed upon measurements with an incorrect chain, the true area may be obtained by proportions similar to those above; thus,

$\overline{66 \text{ feet}}^2$ : $\overline{\text{the length of the inaccurate chain in feet}}^2$ ::
the computed area : the true area.

**30.** Except in measuring perfectly level ground, the chain does not rest on the ground, but is suspended between the two ends. The sagging of the middle must, of course, have the effect of shortening the chain. It is customary in compass surveying, where the character of the operations does not admit of great accuracy, to disregard this error. If, however, precision is required, as in surveying city property, and in engineer-

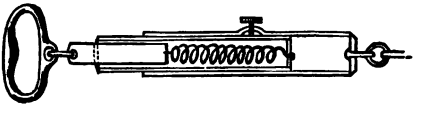


FIG. 16.

ing work, means must be used to obviate it. The most effectual means is the insertion, at the handle, of a spring balance or dynamometer, Fig. 16, the index of which shows the amount of tension. The standard length of the chain is obtained by swinging the chain freely at the ends, and stretching it until the index of the dynamometer marks the standard point.

The spring of such a chain is liable to become weakened by use. The chain must, therefore, be frequently tested by means of a standard line, and the index adjusted.

**31. Tape-lines** are frequently used for the measurement of lines, instead of the chain. The best are made of a thin ribbon of steel, jointed at intervals, and wound up in a leather case. A cheaper measure is made of linen tape, with a fine brass wire interwoven through its length. The common linen tape must be used with caution, as its length is materially affected by being wet.

**32.** Two men are required for measuring a line with a chain, the one in advance being called the **leader**, and the other the **follower**. The leader is provided with ten iron pins, bent into rings at the top and pointed at the bottom. Bright tags are tied to the top rings, to render the pins easily seen. An improved pin is made with the pointed end so heavy that when dropped it will fall plumb below the point where it is held. A few thin rods or staves are also often useful for ranging out lines, and marking their terminations.

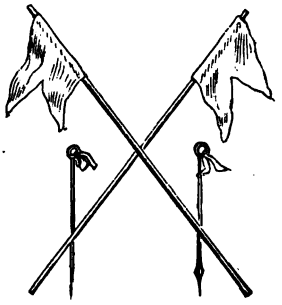


FIG. 17.

The leader, taking an end of the chain and the ten marking-pins, walks directly toward the point to be reached. The follower, holding his end of the chain at the starting-point, by word or gesture ranges the leader exactly in line. Then the leader, assuring himself that the chain is straight and taut, puts down a pin. They then walk on one chain's length, and repeat the same operation. The follower gathers up the pins put down by the leader. In thus measuring a line the number of pins taken up by the follower will be the number of full chains in the line. If all the pins are put down before the line is completed, they are passed back to the leader, and a tally kept for every ten chains.

Care and skill are required to make the measurement trustworthy. If the pins are not truly in line, or the chain is not drawn taut, the distance

will be exaggerated. With all the precautions possible, measurements made over the ordinary rough surface of the ground with the surveyor's chain can only be relied on within very considerable limits. It may be fairly claimed, however, that they are within the limits of accuracy attainable in the other parts of compass surveying. When greater accuracy is required, a chain with a dynamometer attachment should be used and the line should be measured in both directions. Methods for the very precise measurement of a line, which is required in surveys on a large scale, will be given subsequently.

**33.** Since the distances used in surveying are horizontal distances, it is necessary that the chain, in measuring over uneven ground, should be held horizontal. In going down-hill, as in Fig. 18, the leader must hold his end of

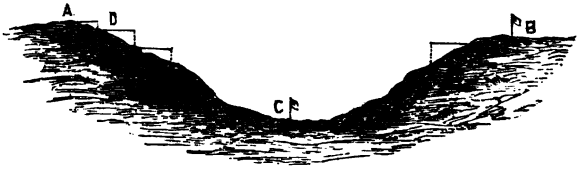



FIG. 18.

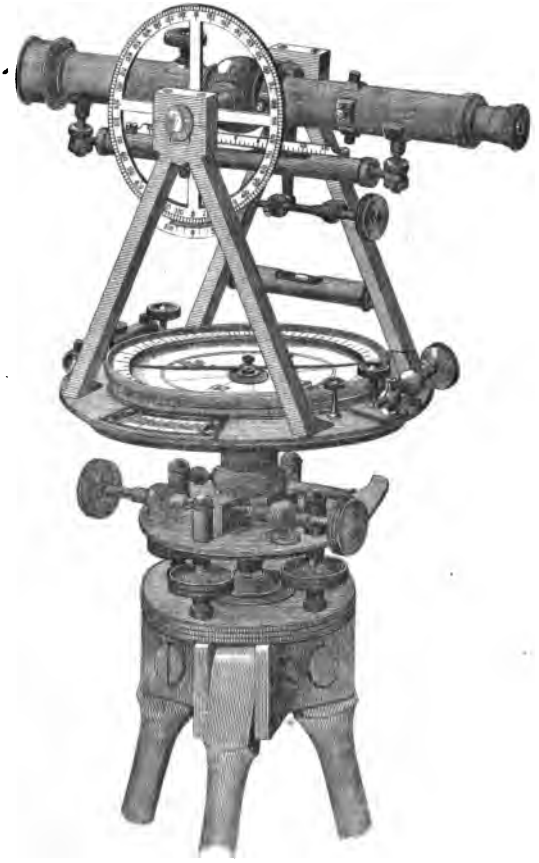
the chain elevated, and in going up-hill the follower. The chainmen depend upon the eye to determine when the chain is level. A small spirit-level is sometimes attached for this purpose. The chain is drawn taut, an allowance is made for sag, and by means of a staff, or by dropping a pin, the point immediately below the elevated end is marked. If the chain provided with a dynamometer is used, no allowance for sag is required.

In case the ground is too steep to admit of using the full chain, the half or quarter chain may be used. The best chains admit of being taken apart for this purpose.

**34.** In chaining across a valley, as in Fig. 18, the follower sometimes is unable to see at the same time the staff at B, and the pin in the leader's hand at D. In this case a plumb-line may be held at A, and when the eye is so held that the line covers B it will also cover the point D. It will be found convenient in such cases, where the difficulty is liable to recur at each chain, to set up, by means of a plumb-line, a stake, at C, the lowest point, and then to range the intermediate points by this.

**35.** If one end of a line cannot be seen from the other because of an intervening elevation, it is necessary to fix intermediate points. This may be done as follows: Let it be required to find intermediate points between A and B, Fig. 19, separated by an intervening elevation. Plant

# SURVEYOR'S TRANSIT.



BENJ. D. BENSON. N.Y.

a staff at $m''$, approximately in the desired line, as shown in the horizontal plan of the figure. Plant another at $n''$, in line with A and $m''$. Sight from $m''$ toward B; if $n''$ is not in line, have it moved to $n'$ in line. Sight from $n'$ toward A, and bring the staff at $m''$ into line at $m'$. Thus proceed, bringing the staves more and more nearly into line, until at last they are found exactly in range at $m$ and $n$.

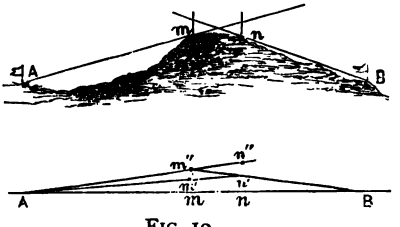


FIG. 19.

**36.** When an **obstacle** interferes with the ranging and measurement of a line, the following expedients may be employed to find the length indirectly.

**By setting off perpendiculars.** Let it be required to find the length of the line AX, Fig. 20, of which the part BC is covered by an obstacle. Measure the part AB. At B erect a perpendicular, BD, of such length as to be clear of the obstacle. At D erect a perpendicular, DE, and.

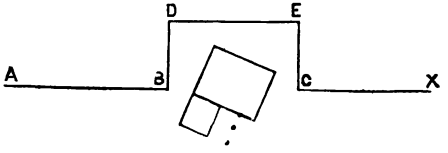


FIG. 20.

measure past the obstacle. At E erect a perpendicular, EC, of the same length as BD. Finally, at C erect a perpendicular, CX; it will be the continuation of the line AB, and DE will be the length of the wanting part.

The right angle in the above problem may be set off by the transit or compass. A small instrument called the surveyor's cross may also be conveniently used. It consists of a staff, on which is mounted a head, having two sights at right angles. The staff is set at the point where the right angle is to be constructed. One set of sights is pointed in the direction of the given line; the other will then point in the direction of a perpendicular. Two slits sawed in a board, at right angles to each other, will, for ordinary cases, take the place of the sights.

A **perpendicular** may also be set off on the ground by means of the chain only. Let it be required to erect a perpendicular at B, Fig. 21, to the line AB. Measure back from B, 40 links to A. Fix one end of the chain at A, by means of a pin, and also fix the 80th link at B.

Then, holding the middle point of the chain, stretch it taut; it will take the position D, which will be the third angle of a right-angled triangle, AD being the hypothenuse, and AB and BD being the two legs.

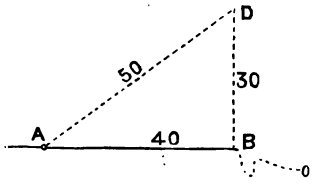



FIG. 21.

**37. By constructing a parallel.** Let it be required to extend the line ABC, Fig. 22, beyond the interposing obstacle, and to obtain its length. At two points, B and C, erect perpendiculars BD and CE, of equal length, and so long that a line running through DE will clear the

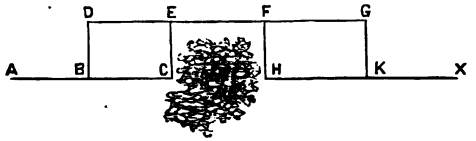



FIG. 22.

obstacle. At two points in this line, F and G, erect perpendiculars FH and GK, equal in length to those on the other side. The extremities of these perpendiculars, H and K, will be two points in the continuation of the line ABC, and EF, when measured, will give the length of the wanting part, CH.

**38. By equilateral triangles.** Let it be required to extend the line ABC, Fig. 23, beyond an obstacle, and also to obtain its length. Set off

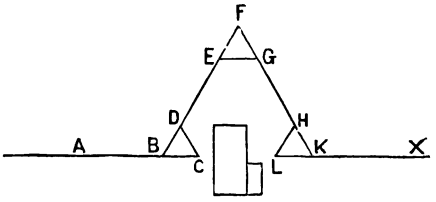



FIG. 23.

BC equal to 50 links. Fix one end of the chain at B, and the other at C; the middle of the chain, when drawn taut, will give D the third angle of an equilateral triangle. Extend BD sufficiently far to clear the obstacle, and construct in the same way the equilateral triangle EFG. Extend FG until FK is equal in length to BF. Construct the equilateral triangle

HLK; LK will be the continuation of AC, and BK will be equal in length to BF or FK.

**39. By symmetrical triangles.** If the obstacle be such as not to prevent ranging across it, but only prevents measurement, the distance may be obtained as follows:

Let AX, Fig. 24, be a line of which the part BF cannot be directly

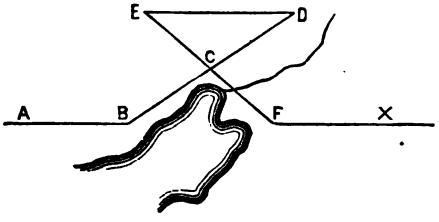



FIG. 24.

measured. Select some convenient point, C. Range and measure a line BCD, so that CD shall be equal to BC. Also range and measure the line FCE, making CE equal to FC. Then measure the distance ED, it will be equal to the wanting part BF.

Other methods for obtaining the length of inaccessible lines will be given under Chapter IV.

**40.** The surveyor will have occasion sometimes to determine the length of a line more accurately than is possible by any of the methods of measurement heretofore described. To accomplish this, some variety of **measuring-rod** must be used.

Rods of iron or brass are often used; and, when a strict estimate is made of the changes of length resulting from temperature, they are capable of almost any degree of precision.

Iron expands, between 32° and 212° Far., .0012575 of its own length.
Brass " " " .0019062 "

The rods are usually made to measure a certain standard length at a given standard temperature. Thus, a rod may be made five and a half yards in length, at a temperature of 60° Far., and in measuring with such a rod, any variations above or below this must be noted and taken into account. Let the temperature, for example, be 80° Far., the correction for the length of an iron rod will be found by the following formula, $l$ representing the standard length of the rod:

$$\text{Correction} = \frac{20^\circ \times .0012575 \times l}{180^\circ} \text{ to be added.}$$

A small thermometer may be attached to the rod, which can be read as occasion requires.

Wooden rods may be advantageously used instead of metal, in ordinary cases. They are very little affected by temperature, and the effect of moisture may be mostly prevented by thoroughly soaking the rods in linseed oil, and afterward covering them with shellac. The best material is yellow pine, selected of straight grain and even texture.

In the rigorous operations required in trigonometrical surveys on a large scale, such as the United States Coast Survey, the best results have been attained by using rods made of several metals combined, on the principle of the compensation pendulum. In the report of the United States Coast Survey for 1854 will be found a detailed description of the rods devised for measuring the base-lines, by Professor A. D. Bache, late superintendent.

**41.** To measure a **base-line** accurately with rods, the first step is to clear it of obstructions, so that it may be seen from end to end. Two rods are required for the measurement. Place one end of the first rod precisely at the beginning of the line, and by means of a transit align it in the required direction, and level it with a spirit-level. Bring the second rod into line by the transit, level it, and bring the extremities into contact. Care must be taken not to disturb the position of the first rod by the jar of the contact. The first rod may now be moved from its position and aligned in contact with the second. Light tripods are used for bringing the rods level, and a light framework to prevent the rods from sagging.

When it is not convenient to measure the whole line on a level, it may be measured on a slope, and a correction made to reduce the distance to a horizontal. Thus, if we desired to find the horizontal distance between A and D, Fig. 25, the part BC having been measured on a slope, we would have

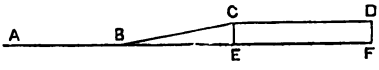



FIG. 25.

$$AF = AB + BE + CD$$

in which

$$BE = BC \times \cos B$$

Hence,

$$AF = AB + BC \times \cos B + CD$$

In this case it is necessary to measure the angle of inclination of the slope, either by the spirit-level or by the vertical circle of the transit or theodolite.

**42.** Methods of measuring lines with dispatch, although with inferior precision, are often of the greatest service to the surveyor. An apparatus called an **odometer** has been devised for this purpose. It consists of a

vehicle in which one wheel is connected with a train of wheelwork in such a way as to record the number of its revolutions by means of an index. Commonly the wheel is made 8 feet 3 inches in circumference, so that two revolutions cover one rod. On level ground such an instrument will give tolerably correct results; but where it is undulating the distance recorded will be the surface-distance, and not the required horizontal distance. It is also supplied with a magnetic compass, so that the surveyor may record the bearings of the line while the wheel records the distances.

This instrument has been much used in making rough surveys for county and township maps, and, in the hands of a skillful surveyor who knows how to make proper allowances, it has proved a very useful invention. It has been used in the United States Coast Survey for filling up details of roads, etc.

**43.** The **micrometer telescope** furnishes a beautiful method of obtaining distances with considerable precision. A pair of parallel threads, Fig. 26, is inserted in the focus of the telescope of an ordinary surveyor's transit. These threads are commanded by a pair of fine thread mill-head screws. They can be made to coincide at the centre of the field, or by the screws withdrawn from each other any distance. A rod divided into feet, etc., is placed at a convenient distance, say 100 feet. The telescope is then pointed at the rod and focused. The threads of the micrometer are now made to cover a given space in the rod, say one foot. It is evident if the rod be removed to twice the distance, the threads will cover two feet, and so on in the same proportion.

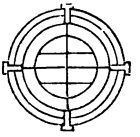


FIG. 26.

Let it now be required to determine the distance across a lake, or some other distance not easily accessible. Adjust the threads, as stated, to the space of one foot on the rod; send the rod to the desired point, and set it

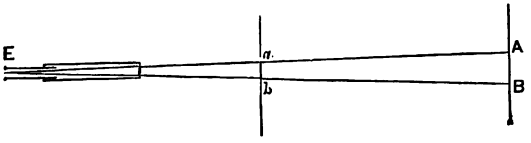



FIG. 27.

up perpendicular to the line of sight; bring the telescope so that one thread shall coincide with an even foot. Signal to the assistant until he slides a mark or target on the rod, so that it shall exactly coincide with the other thread. The space covered on the rod will enable us to determine the distance. Let E, Fig. 27, be the position of the eye, *ab* the

space covered on the rod by the threads when at the distance 100 feet, and AB (= $m$) the space covered by the threads at the unknown distance EA. Then, by similar triangles, we have

$$ab : AB :: Ea : EA$$
$$1 : m :: 100 : EA$$
$$EA = m \times 100$$

Let the space covered on the rod be, for example, 5.45 feet:

$$EA = 5.45 \times 100 = 545$$

In the hands of a skillful observer this apparatus will give results nearly or quite equal to the best measurements which can be made with a chain. The manufacturers of transits for surveyors now insert in the telescopes the micrometer, at little or no additional cost.

# CHAPTER III.

## MEASUREMENT OF ANGLES.

**44.** ANGLES are the second class of magnitudes which, in surveying, admit of direct measurement, and which, together with the measured lines, enable us to determine the unknown lines and areas which we require.

An **angle** is the inclination of two lines. A **horizontal angle** is one in which the lines are horizontal, and which consequently lies in a horizontal plane. A **vertical angle** is one which lies in a vertical plane. If

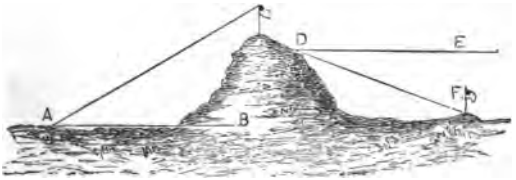



FIG. 28.

one side of a vertical angle is horizontal, and the other lies above it, it is called an **angle of elevation.** If one side is horizontal and the other lies below it, it is called an **angle of depression.** In Fig. 28, BAC is an angle of elevation, and EDF an angle of depression.

An **oblique angle** is one whose sides are neither both in a horizontal

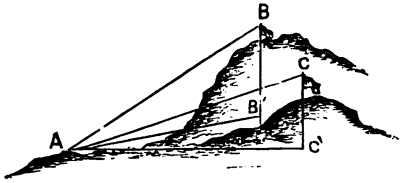



FIG. 29.

plane, nor both in a vertical plane. The angle formed by two lines meet-

ing at some point, as A, Fig. 29, and running to the tops of two mountains of unequal height, would be an oblique angle.

The two kinds of angles used in Land Surveying are horizontal and vertical, and the Chapter will be restricted to describing the measurement of these.

**45. A circle divided into 360 equal parts** is universally employed for the measurement of angles. One of these parts is called a degree, which is subdivided into 60 equal parts called minutes, and these again into 60 equal parts called seconds. If two lines, as AC and BC, Fig. 30, intersect each other in the centre of such a circle, the number of these equal parts which they include between them in the circumference of the circle (in this case 50) will give the angle which they make with each other. As shown in Art. 10, Chap. I, such measurement of angles is independent of the size of the circle on which it is made.

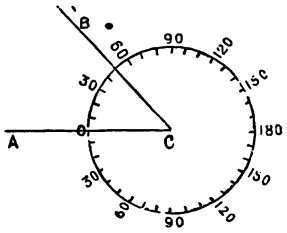


FIG. 30.

The chief instruments employed in surveying, according to American practice, for the measurement of angles, are **The Transit, The Surveyor's Compass,** and **The Theodolite.** The last of these, however, has nearly disappeared in American surveying, and its place is supplied by attaching a vertical circle to the Transit. A description of these instruments will now be given.

## SURVEYOR'S COMPASS.

**46.** The essential parts of a Surveyor's Compass are the divided circle, the magnetic needle, and the sights. The form and arrangement of the complete instrument will be seen in the plate opposite.

The **magnetic needle** is a small bar of steel, the length of which nearly equals the diameter of the divided circle. At its middle is a small cap with a steel or jewel centre which serves to suspend it upon a steel pivot at the centre of the circle. It is made to balance after being magnetized,

FIG. 31.

by a small coil of fine wire around the south end, which may be moved until it be exactly poised. The delicacy of the needle may be tested by the number of vibrations which it will make after being disturbed, before

coming to rest. The greater the number of vibrations before coming to rest, the greater the magnetic force, and delicacy of suspension.

The needle, when suspended freely, assumes a direction nearly north and south, which is termed the **Magnetic Meridian.**

**47.** The **circle** of the ordinary Surveyor's Compass is divided into degrees and half-degrees, and is numbered 0 at the north and south points, right and left up to 90° at the east and west points. This circle is attached to a plate provided with two **sights** placed on opposite sides of the divided circle. A straight line running through the two sights will pass through the centre of the circle at which the needle is suspended, and through the north and south points. They are placed precisely perpendicular to the plate to which they are attached, and are capable of being removed when the instrument is to be packed. Each sight has one narrow slit and one wide slit in which a thread is inserted. The narrow slit in one is opposite to the wide slit in the other. When pointed at an object the eye is placed at the narrow slit, and the instrument turned until the thread in the wide slit crosses the target.

**48.** Two small **spirit-levels** are attached to the plate of the compass for the purpose of determining when the instrument is level. They are placed at right angles to each other, and their axes are made parallel to the plate. When the two spirit-levels are horizontal the plate is horizontal in every position.

The spirit-level consists of a glass tube, slightly but uniformly curved, and closed at both ends. The tube is nearly filled with spirits, leaving a small bubble of air. When placed with the curvature upward, and the two ends exactly in the same level, the air-bubble will run to the middle. If one end is raised, the air-bubble indicates the fact by running toward the elevated end. To make the plate of the compass, therefore, horizontal, we have only to move it until the bubbles are brought to the middle point of the two tubes.

FIG. 32.

FIG. 33.

**49.** The Compass is supported on a **ball-and-socket joint** or on a **tripod-head.**

The construction of the ball-and-socket joint will be apparent from Fig. 33. The ball is shown by the dotted line enclosed in the socket. This joint permits motion in any direction, and is made to move with sufficient friction to maintain the compass in its place. For the purpose of levelling the compass, the plate is grasped in the hands and moved on this joint until the bubbles occupy the middle of the tubes.

In sighting the instrument the level of the plate is liable to be disturbed, by moving it by hand into the required line. To obviate this difficulty, as well as to render the pointing of the instrument more accurate, a clamp and tangent screw are attached to the ball of the joint. It is shown in the plate of the compass, just below the brass plate bearing the sights.

A staff with an iron-shod point, commonly called a **Jacob's staff**, is used to support the ball-and-socket joint and the compass. The compass, joint, and staff may all be detached from each other when desired. Instead of the Jacob's staff, a **tripod** may be used to support the instrument. It gives greater steadiness to it while it is levelled and used.

**50.** To facilitate the exact levelling of the instrument, a contrivance called a **tripod-head**, Fig. 34, is used instead of the ball-and-socket joint above described. It consists of two brass plates connected together by a ball-and-socket joint. The lower plate is connected by means of a large screw to a brass plate, which forms the top of the tripod. Between the two plates of the tripod-head are four thumb-screws placed at opposite points, resting on the lower plate, and passing up through the upper plate. By means of these we can change at pleasure the position of the upper plate and the instrument supported on it. The spindle or axis of the compass fits into a conical opening which runs down into the neck of the ball-and-socket joint.

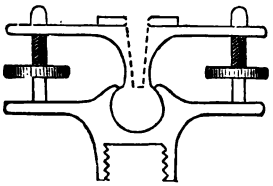


FIG. 34.

**51.** When supplied with a tripod-head, the compass may be **levelled** as follows:

1. Bring the plate as nearly level as possible by moving the legs of the tripod and watching the effect upon the levels.

2. Turn the compass so that one of the spirit-levels shall be parallel to one pair of levelling screws, and the other to the other pair.

3. If the bubble stands in the middle of either level, the plate is level in that direction. If the bubble is not at the middle of a tube, bring it there by means of the pair of screws parallel to it. Grasp both screws with the fingers and thumbs, and turn both at the same time an equal amount, one to the right and the other to the left. This motion raises the plate on one side and depresses it on the opposite. By watching the bubble the motion can be arrested at the right moment. When the one tube has been brought level, the same process may be used with the other. If, in levelling the second, the first has been disturbed, it must again be brought level; and this must be continued till

both tubes are brought level. Since two lines determine the position of a plane, when the plate is level in these two directions it is horizontal.

**52. To measure a horizontal angle by means of the compass,** proceed as follows:

1. Place the compass precisely over the angular point A, Fig. 35. The tripod is provided with a plumb-bob for this purpose.

2. Level the instrument in the manner described.

3. Turn the sights of the instrument along one of the lines forming the angle, as AB, pointing it carefully upon some well-defined signal. It is customary with most surveyors, in using the compass, to make the north end of the plate always point towards the signal. In that case the angle should always be read from the north end of the needle. The E and W letters on the face of the compass are usually put on in the reverse from their natural position, in order that the direction of the line of sight may always be correctly read.

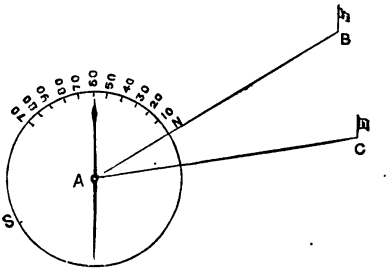



FIG. 35.

4. Note the reading indicated on the circle by the north end of the needle. If it lies between the N and E points, the line is northeast, etc. The north end of the needle is always distinguished by some peculiarity of shape or color. The circle is never divided nearer than to half degrees, but, by eye, the surveyor can easily estimate to the nearest quarter. This being the degree of precision usually employed in the traverse tables, no nearer reading is generally attempted with the compass.

5. Turn the line of sights toward the second signal, AC, and having accurately pointed it, read as before.

These two readings, when **properly combined**, will give the angle included between the lines AB and AC.

**53.** The following obvious rules for combining the readings to obtain the included angle will be found convenient. The propriety of the directions will be apparent from considering the annexed figure.

1. When the readings are both north or south, and both east or west, the included angle is equal to the difference between the readings. Thus,

$$AOB = NOB - NOA$$

2. When the readings are both north or south, and one east and the

other west, the included angle is equal to the sum of the two readings. Thus,

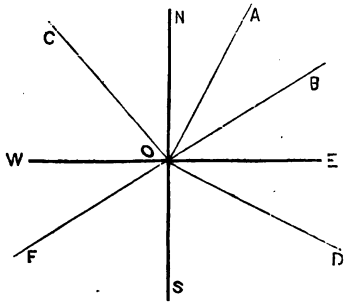



FIG. 36.

$$AOC = NOA + NOC$$

3. When the readings are both east or west, and one north and the other south, the included angle is obtained by subtracting the sum of the two readings from 180°. Thus

$$AOD = 180° - (NOA + SOD)$$

4. When one reading is north and the other south, and the one east and the other west, the included angle is obtained by subtracting the difference of the two readings from 180°. Thus,

$$AOF = 180° - (SOF - NOA)$$

EXAMPLES.

1. The line AC reads N 54° 30′ E,
   the line AB reads N 25° 45′ E: what is the included angle?
2. The line AB reads S 48° 15′ E,
   the line AC reads S 19° 30′ W: what is the included angle?
3. The line AB reads N 60° 30′ E,
   the line AC reads S 16° 0′ E: what is the included angle?
4. The line AB reads S 73° 45′ W,
   the line AC reads N 43° 30′ E: what is the included angle?

**54.** The angle which a line makes with a true North and South line is called the **bearing** of that line. Thus we say that a line from the City Hall, New York, to Sandy Hook Light-house, bears South 0° 47′ East. The angle 0° 47′ is the bearing of the line.

When we reckon the bearing from the magnetic needle, instead of the true meridian, it is called the magnetic bearing. The angles read from the surveyor's compass are the magnetic bearings. If the magnetic needle pointed due north and south, the magnetic bearings and true bearings would coincide. Or, if the magnetic needle always varied from the true meridian by a constant amount, the angle between two lines measured by referring them to the magnetic needle, would be the same as by referring them to the true meridian.

In Chapter VII will be found an account of the variation of the needle,

and the methods by which it may be ascertained, and the errors arising from it in practical surveying may be obviated.

## VERNIER.

**55.** The object of a **vernier** is to enable us to read smaller divisions on any scale than would be possible with a simple index. It may be applied to the divisions on a straight scale as a levelling-rod, or of a curved scale as a graduated circle of a compass or transit.

Let Fig. 37 represent part of the circumference of a circle in an angular instrument divided into degrees and half-degrees. This is com-

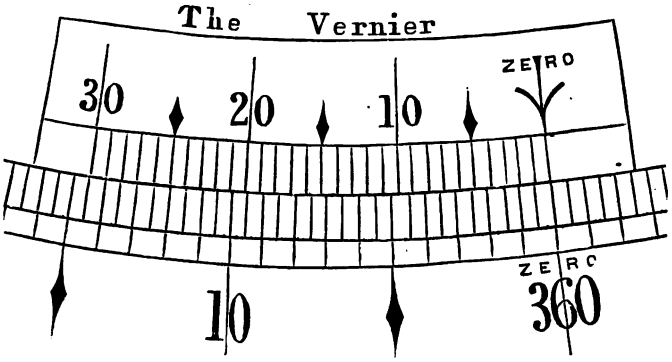



FIG. 37.

monly called the **limb.** And let the line marked 0, or zero, on the inner concentric circle, called the **vernier,** represent a movable index, which may point successively at all points of the outer divided circle. With this arrangement only, it is plain that the smallest division of the circle which could be indicated with accuracy would be half-degrees.

Suppose a space corresponding to 29 divisions on the limb were marked off on the vernier circle, to the right and left of the index-mark 0. Let this space now be divided into 30 equal divisions.

Since 29 divisions on the limb = 30 divisions on the vernier,
30 divisions on the limb exceed 30 divisions on the vernier by one division of the limb.

**Hence,** 1 division on the limb exceeds 1 division on the vernier by $\frac{1}{30}$ of one division of the limb.

If the divisions of the limb are half-degrees,

1 division on the limb exceeds 1 division on the vernier by $\frac{1}{30}$ of half a degree, that is, by 1 minute.

If now the 0 point of the vernier be made to correspond with 0 degrees on the limb, the first division of the vernier will fall short of reaching the first division on the limb by 1 minute; the second division, 2 minutes, etc. And if the vernier circle be moved until the first divisions correspond, it must have been moved 1 minute; if the second divisions correspond, 2 minutes, etc.

Let us suppose, now, that in pointing the instrument the index of the vernier falls somewhere between two divisions of the limb, as shown in

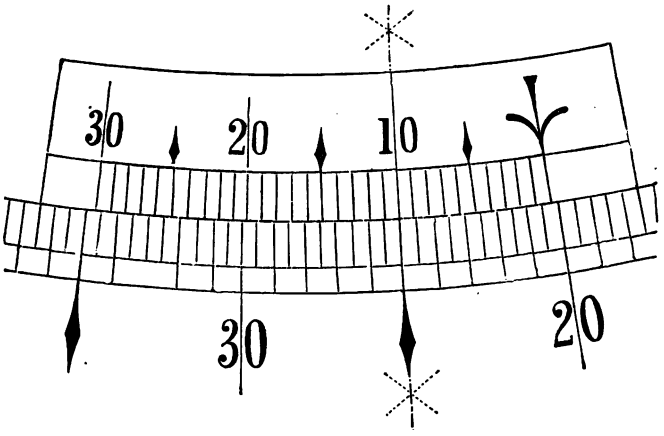



FIG. 38.

Fig. 38. First, we note at how many degrees and half-degrees from the 0 point of the limb the index falls; in this case 20°. Then we trace along the vernier until we find one of its division lines, which matches exactly a line of the limb; in this case we find that the (10th) line of the vernier matches a line of the limb. This indicates that the index of the vernier stands 10 minutes beyond the last half-degree; and hence the reading of the instrument will be 20° 10′.

In circular instruments the verniers are made to read in both directions, that is, to the right and left from the index-point. In all cases, in reading verniers constructed as above described, we use the forward end, that is, the end toward which the numbering on the limb proceeds.

Verniers may be constructed in which 31 divisions of the limb are equivalent to 30 divisions on the vernier. In these it is plain that one division on the limb will be less than one division on the vernier by $\frac{1}{30}$ of one division on the limb; that is, if the divisions are half-degrees, by one minute. In reading such a vernier, we read from the rear end instead of the forward end.

**56.** On the same principle verniers may be made to read to any desired degree of precision. Thus, a circle may be divided into thirds of degrees, and a vernier having 60 divisions used. One division of the limb would differ from one division on the vernier by $\frac{1}{60}$ of a third of a degree, that is, by $\frac{1}{3}$ of a minute, or 20 seconds. Such an arrangement therefore would enable us to read angles to 20 seconds.

Upon levelling-rods, scales, and other straight instruments, the verniers are made to indicate divisions of a foot, or an inch.

## VERNIER COMPASS.

**57.** David Rittenhouse, of Philadelphia, introduced an improvement in the common surveyor's compass, by attaching a vernier to the graduated circle. The object of the improvement was to facilitate the running of lines when it was necessary to take into account the variation of the magnetic needle. In the plate of the compass opposite Art. 46, the vernier will be seen at the left end of the figure. An arc of a circle reading half-degrees is attached to the plate which carries the sights, and is concentric with the graduated circle and the needle. A vernier is arranged to move along this arc by a slow-motion screw, shown in the figure. This vernier is connected with the graduated circle, so that when the vernier is moved by the screw the whole graduated circle is carried along with it. The arc through which it is moved can be read in the manner described.

**58.** This vernier attachment of the compass subserves two objects:

*First:* In determining the bearing of any line by means of the compass, if the needle does not point exactly at any division line of the circle, the additional arc may be determined by turning the vernier-screw until the last previous division coincides exactly with the end of the needle; the arc through which the index-point has been moved, read off from the vernier, will give the additional arc required.

Since the precision with which the common compass-sights can be pointed on any object, is ordinarily not greater than can be estimated directly from the pointing of the needle on the graduated circle, this use of the vernier attachment is but little resorted to.

*Second:* The more important use of the vernier in the compass, is to

enable us to set off by means of it the variation of the needle, and thus to measure the bearings of lines from the true meridian instead of the magnetic meridian.

Suppose the variation of the needle at any place to be 5° 13′ west. Turn the vernier-screw until the vernier shall indicate 5° 13′ on the side toward which the needle varies. It is plain that when the line of sights is turned so that the needle shall read zero on the circle, it must point in a direction 5° 13′ east from the needle, and, therefore, must be due north and south. The compass, when thus set, will give the true bearings of all lines. If, however, the compass is removed to another locality, where the variation of the needle is different, it will require to be set anew to correspond to the changed variation.

The vernier compass will also facilitate the re-running of the lines of an old survey. Place the instrument on some well-defined line of the old survey, and turn the vernier-screw until the needle of the compass indicates the same bearing as that given in the old field notes. The reading of the vernier, when thus set, would give the variation of the needle at the time of the old survey. All the other lines of the survey may now be run without further alteration, and the new bearings ought to agree with the old.

**59.** To increase the precision with which the compass may be pointed, a **telescope** is now often made to take the place of the sights. The construction of the telescope and the manner in which it is supported will be shown in full in the description of the transit. The advantage of the telescope in the compass consists in the fact that with it the target can be more distinctly seen, and seen at a much greater distance, and, by the apparatus for pointing the line of sight, can be more exactly directed toward it than is possible with the ordinary sights.

## THE TRANSIT.

**60.** The plate opposite represents a transit of such form as is commonly employed by American surveyors. It is used to measure angles with greater accuracy than can be done by the surveyor's compass above described. To this end it is supplied with a telescope, and the angles are read, not from the end of the needle, but from the indications of a vernier upon a divided circle. It is supported on a tripod, and the arrangement for levelling it by means of a tripod-head is the same as has been described under the compass.

**61.** The part of this instrument which serves to measure horizontal angles consists of two concentric horizontal plates. The lower plate, called the **limb**, turns on a spindle, or axis, which fits into a socket in the

# VERNIER COMPASS.

BENJ. D. BENSON, N.Y.

NOT FOR LOAN

tripod-head. By means of a clamp and tangent-screw, shown in the figure, it may be clamped fast in any position, and made to move slowly through a small arc. The circumference of this plate is graduated in divisions, usually of halves or thirds of degrees. In the transits used by surveyors these divisions are numbered from some one point on the limb in both directions around to the opposite point, which will be 180°. The graduation is generally concealed beneath the plate above it, except at those parts where the verniers are for the time turned.

**62.** The upper plate, called the **vernier-plate**, turns on a spindle fitted into a socket in the lower plate. It is also provided with a clamp, by means of which it can be clamped fast at any point, and with a tangent-screw, by which it can be turned through a small arc. These are shown in the figure at the outer rim of the vernier-plate.

This plate has two verniers at opposite sides, each of which enables us to read smaller subdivisions of the divisions on the limb. The principle of the vernier in the transit is the same as that described under the head of the compass. Thus, let the limb of the transit be divided into half-degrees, the vernier, by having 30 divisions, equivalent to 29 or 31 divisions of the limb, will indicate a subdivision of the limb equivalent to one-thirtieth of half a degree, or 1 minute.

The advantage attained by having two verniers located at opposite points of the circle lies in the fact that by this means is obviated any error which may arise from a want in the exact coincidence of the centres of the vernier-plate and limb. Thus, let C, in Fig. 39, be the centre of the limb, and C′ the centre of the vernier, and let VV′ be a line running through the 0-points of the two verniers. It is plain that the distance of V from 0° is just as much too small as the distance of V′ from 180° is too large. Hence, if we take the reading of the vernier V and the supplement of the reading of V′, and add them together, and divide the sum by two, the result would be the true reading of the vernier V, freed from the error caused by the displacement of the centre C′.

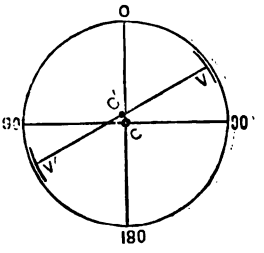


FIG. 39.

**63.** A needle and a divided circle, as shown in the plate, are a common but not an essential accompaniment of the transit. It may serve as a rough check on the readings of the angles by the verniers; it will give us at any step the magnetic bearing of a line; and, finally, it will enable us to use the transit as a common compass for the surveying of land and the re-establishment of lost lines.

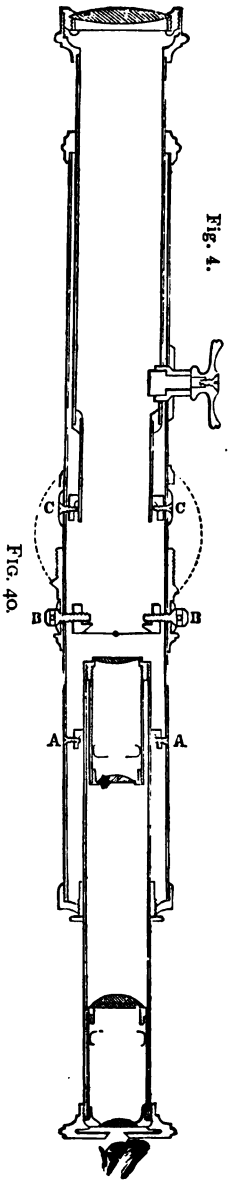



FIG. 40.

Fig. 4.

**64.** The telescope is supported on two firm **columns**, which are attached to the vernier-plate. The columns are sufficiently high to permit the telescope to be reversed by revolving on its axis. The axis of the telescope is made parallel to the vernier-plate, and at right angles to the centre line or axis of the telescope.

Most transits used in surveying have a **vertical circle** attached to one end of the axis of the telescope. It is divided into degrees and parts of degrees, and, by means of a vernier, may be read in the same manner as the horizontal circle. This circle is set so that when the telescope is horizontal the vernier shall read 0, and enables the surveyor to measure vertical angles.

Two **spirit-levels** are attached to the vernier-plate for the purpose of levelling the instrument. They are placed at right angles to each other, and are used as explained for levelling the compass.

**65.** The **interior mechanism** of the telescope used in the transit can be seen from the adjoining figure. The lens placed in the end of the telescope, which is turned toward the object, is called the **object-glass**. The four lenses placed at the opposite end in a smaller tube compose what is called the **eye-piece**. By means of the object-glass, rays of light coming from some distant object upon which the instrument is turned, are converged, and form a minute but distinct image of the object at the focus B. The eye-piece shows this image to the eye enlarged. In the telescope used for astronomical purposes, the eye-piece consists of two lenses, which shows the image inverted; but, in telescopes used for surveying, an erecting eye-piece consisting of four lenses is used.

An imaginary line running through the optical centre of the object-glass and of the eye-piece is called the **line of collimation**, or the **axis** of the telescope.

**66.** At the focus of the telescope, marked BB in the figure, is placed a ring carrying two **cross-threads**, one placed horizontal and the other vertical. The ring is so placed in the tube that the intersection of the two threads is exactly in the line of collimation, and forms a point by

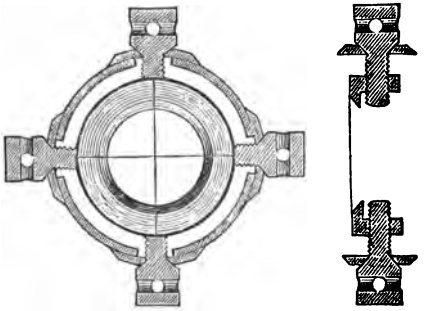


FIG. 41.

means of which the telescope may be directed upon any object. The ring is held in its place by four screws, as shown in Fig. 41, in which is given a cross-section of the telescope tube at the cross-threads. The material which experience has shown to be most suitable for these cross-threads is the natural thread spun by the spider. It is exceedingly fine, strong, and elastic, and when once drawn tense remains unchanged. The threads are fastened to the brass ring by beeswax or varnish.

**67.** Both the object-glass and the eye-piece are placed in separate tubes, which may be moved in or out as required, by a rack-and-pinion movement. Before making an observation with the telescope, the eye-piece should be moved in or out until the cross-threads are distinctly seen, and until, when the head is slightly moved from side to side, no motion appears to take place in the threads. Then the object-glass must be moved in or out until the object is distinctly visible. Each change of distance will require a change in the focusing of the object-glass; and, if different observers use the same instrument, the focusing of both the eye-piece and object-glass may require slight alteration.

**68.** A **spirit-level** is attached to the under side of the telescope, and is made parallel to the centre line of the telescope. It serves to indicate when the telescope is horizontal.

## ADJUSTMENTS OF THE TRANSIT.

**69.** From the preceding description of a transit, it must be apparent that the various parts of the instrument require to be brought into certain

exact and definite relations with each other, in order that its functions may be satisfactorily performed. The detection of any deviations from this just relation of the parts, and their rectification, compose what are termed the **adjustments** of the transit. Aside from those which are made by the manufacturer, and which are not liable to be disturbed in the ordinary use of the instrument, there are five principal adjustments.

1. The plane of the levels on the horizontal limb must be perpendicular to the axis on which it revolves.

2. The line of collimation of the telescope must be at right angles to the axis of the telescope; so that when the telescope rotates on its axis the line of collimation will generate a plane surface.

3. The axis of the telescope must be parallel to the plane of the levels on the horizontal limb; so that when the horizontal limb is levelled the axis of the telescope shall also be level.

4. The spirit-level attached to the telescope must be parallel to the line of collimation; so that when the level tube is made horizontal, the line of collimation shall also be horizontal.

5. The vertical circle must be so placed that the vernier shall read zero when the telescope is horizontal.

**70. To adjust the levels of the horizontal limb.** Turn the horizontal limb so that one of the spirit-levels shall stand parallel to a pair of levelling screws. By means of the screws bring the bubble to the middle of the tube. Turn the instrument half-way around; if the bubble still remains in the middle of the tube, the axis of the tube must be at right angles to the axis of the limb. If the bubble runs to one end, that end of the tube must be too high. By means of the screws for the purpose, lower this end or raise the opposite, until the bubble recedes half-way back towards the middle. By the levelling screws bring the bubble once more to the middle. Repeat the operation until reversing the position of the limb does not disturb the position of the bubble.

Each of the level tubes must be adjusted separately.

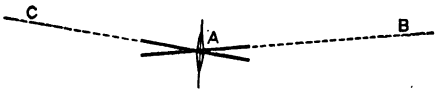



FIG. 42.

**71. To adjust the line of collimation.** If the line of collimation is not perpendicular to the axis, the direction in which the telescope points, when looking forward, and the direction looking backward, will not be in the same straight line. Thus, in Fig. 42, when the telescope is directed to the right it may point in the line AB; but when reversed, by revolving it on its axis and directed to the left, it may point in the line AC. If

the line of collimation were perpendicular to the axis, these lines would coincide; if not, they will, as in the figure, diverge. To make the adjustment, proceed as follows:

Set the instrument on some convenient ground and level it carefully by the levelling screws. Adjust the focus of the eye-piece to the cross-threads, and point the telescope on some well-defined object, making the intersection of the threads exactly coincide. Clamp the limb and vernier-plate of the instrument in this position. Revolve the telescope on its axis, and place some well-defined mark at about the same distance as the first, and in the direction indicated by the reversed telescope. Unclamp the vernier-plate and turn the instrument half-way round, pointing the cross-hairs carefully upon the first mark. Again clamp the vernier-plate in this position, and revolve the telescope on its axis toward the second mark. If the line of collimation is perpendicular to the axis, when reversed this second time, the intersection of the threads will point exactly upon the second mark. If, however, when reversed, the intersection of the threads falls to one side of the mark, a point half-way between this new direction and the mark must be the direction in which it ought to point. Thus, in Fig. 43, let A represent the position of the instrument. Point first at a mark, B; then revolve and set a mark, at the same distance, at C, in the direction of the threads. Unclamp and turn back toward B. Clamp and revolve the telescope on its axis. Let D represent the direction in which it now points. It is plain that neither AC nor AD is the continuation of AB, but a line, AE, lying midway between them, is its continuation.

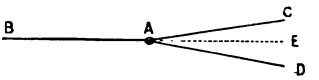



FIG. 43.

The cross-threads must, therefore, be moved so that the intersection shall point toward E. This is done by the screws shown at BB, in Fig. 40. Loosen one of these and tighten the other until the intersection is made to point toward E; remembering that on account of the inversion of the position of the wires by the eye-piece, we must move the wires in a direction opposite to that apparently required. The operation must be repeated until no deviation can be observed.

**72. To make the axis of the telescope parallel to the plane of the spirit-levels.** If the standards which support the axis are perfectly equal the axis will be parallel. If the axis is parallel to the spirit-levels, whenever the plane of the levels is made horizontal, the axis will be horizontal, and the line of collimation of the telescope, when revolved on this axis, will describe a vertical plane. This may be tested by observing whether, when the telescope is revolved up and down, the intersection of the threads will follow a vertical line.

Level the instrument in some position where the top and base of some high object, as a steeple, can be seen. Direct the telescope at some definite point at the top of the steeple, as B, Fig. 44. Clamp the horizontal limb and vernier-plate. Revolve the telescope down and mark the point C, indicated by the intersection of the threads near the bottom of the steeple; the line BC ought to be vertical. Turn the vernier-plate of the instrument half-way round and direct the telescope again to B. Clamp the vernier-plate and revolve the telescope down. If the axis of the telescope were not horizontal, when revolved down, its point of direction, D, would now err as far to one side of a true vertical, BE, as the point C had done to the other side. The end of the axis on that side toward which the telescope deviates from a vertical is too high.

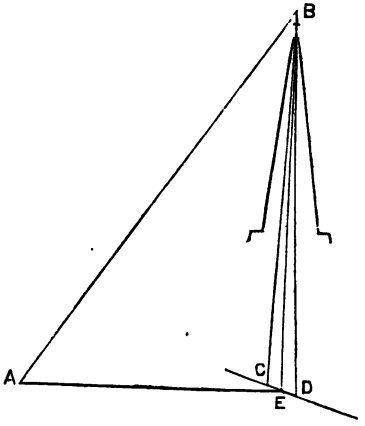



FIG. 44.

Instruments are usually made with one of the standards adjustable, so that the end of the axis may be slightly raised or lowered. By trial we ascertain when this has been sufficiently done to make the adjustment perfect.

**73. To adjust the level attached to the telescope.** This level tube requires to be made parallel to the line of collimation, so that when the level tube is horizontal, the line of collimation of the telescope will also be horizontal.

To effect this, select a space of ground nearly horizontal. Plant the instrument near the middle, and level the horizontal limb. Bring the telescope into such a position that the bubble of the attached level shall be in the middle, and clamp it fast. Set a stake in the ground at a distance of one or two hundred feet, and on this stake set a staff. Note the height on this staff indicated by the cross-threads of the telescope. Set another stake in the ground in an exactly opposite direction, and at the same distance. Set the staff on this stake, and note the height indicated on it by the cross-threads of the telescope when turned upon it. The difference between the two heights will be the difference of level between the two stakes.

Move the instrument and plant it by means of a plumb-line directly

over the lower of the two stakes. Level the horizontal limb, and also the spirit-level attached to the telescope. Measure carefully the height of the axis of the telescope above the stake over which it stands. From this subtract the difference of level between the two stakes, and note the remainder upon the staff. Set the staff on the higher stake and point the telescope at the mark above obtained. The telescope must then be level.

By means of the screws provided for this purpose, move the spirit-level, until, in this position of the telescope, the bubble stands in the middle. The level tube must now be horizontal, and therefore parallel to the line of collimation of the telescope.

**74. To adjust the 0-point of the vertical circle.** When the telescope stands horizontal, the index of the vertical circle ought to read exactly zero.

Having adjusted the spirit-level attached to the telescope, bring the horizontal circle to a level by the levelling screws, and also make the telescope and its attached level horizontal. The vernier of the vertical circle ought now to read zero. If not, its real reading is called the **index error**. Loosen the screws which hold the vertical circle, and carefully turn it until the reading is made precisely zero.

It is not always easy to make this adjustment so that no index error will remain. The index error should in that case be carefully noted, and whenever a vertical angle is measured this correction must be applied to it.

## MEASUREMENT OF ANGLES.

**75. To measure a horizontal angle with the transit.** Let it be required to measure the horizontal angle BAC. Place the transit directly over the angular point by means of a plumb-line. Level the horizontal limb, and clamp one of the verniers at the 0-point of the circle. Turn the telescope upon the target at B, and clamp the limb. Unclamp the vernier-plate and turn the telescope upon the other target at C. Read the vernier which had been set at zero, and the reading will be the horizontal angle through which the telescope turned from B to C.

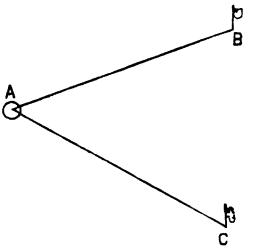


FIG. 45.

It is not necessary to set the vernier at zero before pointing at the first target. The result will be the same if the vernier is read when pointed at the first target, and then read when pointed at the second target. The difference between the readings will be the angle required. Care must be taken, however, in

this method, that when, in turning from the first to the second target, the vernier passes the 0-point or the 180°-point, we must add the readings in the first case, and add the supplements of the readings in the second case.

When precision is required in the measurement of these angles, both verniers should be read for each object. A mean taken between the results got from the two verniers, will, as was shown in explaining the vernier, be free from any error caused by inaccurate centering of the vernier circle and the limb.

**76.** To eliminate as far as possible errors of observation in measuring angles, the operation must be repeated several times, and the **mean** of the measurements taken. On the principle that the measurements have precisely the same probability of being too large as too small, the mean of many observations will be more accurate than any one.

This repetition is best performed with the transit in the following manner:

Point the telescope at the first target B, and read.

Clamp the limb, unclamp the vernier, and turn the telescope on the second target C, and read (1).

Clamp the vernier, unclamp the limb, and turn back to the first target B; clamp the limb, unclamp the vernier, and turn to C, and read (2).

Proceed thus to turn back to B, retaining each time the reading at C.

It is plain that the difference between the successive readings at B and C must give successive determinations of the required angle; and that, omitting the intermediate readings, the difference between the first reading on B, and the last on C, divided by the number of repetitions, must give the mean of all the readings. This method has the advantage of bringing into use different portions of the graduated circle, so that errors from any imperfections in the graduation will be to a certain extent eliminated.

**77.** It will add to the accuracy of the method above described to continue it in a **reverse** order. That is, after noting the last reading at C, unclamp the vernier and turn back to B. Then clamp the vernier and unclamp the limb and turn to C. So proceed until the process has been exactly retraced. Lastly, read the vernier when pointed at B. The difference between this reading and the last in the direct process will be the sum of all the repetitions, which, being divided by the number of repetitions, will give another determination of the angle.

The advantage gained by this reversion is, that thereby the error arising from a slight dragging of the limb by the vernier-plate at each turn is eliminated. In the direct series of measurements this dragging would tend to decrease the measured angle; but in the reverse process the dragging of the limb would tend to increase the measured angle. Hence, the mean of the direct and reverse results must be free from this error.

**78.** It will be observed that the angles measured by the method above described are **horizontal angles**, because they are read from a horizontal circle. Since the telescope, in revolving on its axis, moves in a vertical plane, the angle indicated on the horizontal circle will be the same when the telescope is pointed at B and C, Fig. 46, as when pointed at B′ and C′, which lie vertically beneath them.

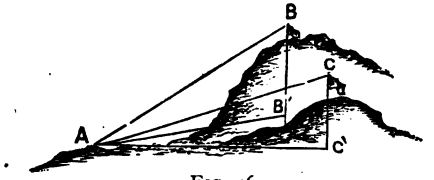



FIG. 46.

The angles, therefore, which are measured between lines on the earth's surface by the transit or compass are not the real angles, except when the lines are horizontal, but are the projections of the real angles on a horizontal plane. As, in surveying, we have to deal with horizontal distances between points and horizontal angles between lines, it is an advantage that the angles measured are horizontal angles.

In case the sextant or reflecting circle is used for measuring the angles, the measurements require a correction to reduce them to their corresponding horizontal angles.

**79. To measure a vertical angle with the transit.** Set the instrument, by means of a plumb-line, directly over the station, Fig. 47, and level the horizontal limb. Examine the vertical circle to see whether it is in adjustment. If not, note its index error. Point the telescope at B, bringing the intersection of the cross-threads upon the point. The angle indicated on the vertical circle by the vernier, corrected, if necessary, for the index error, will be the angle BAC, which is called an angle of elevation. If the object, B, is lower than the instrument, the line AB will lie beneath the horizontal line AC, and the angle would be an angle of depression.

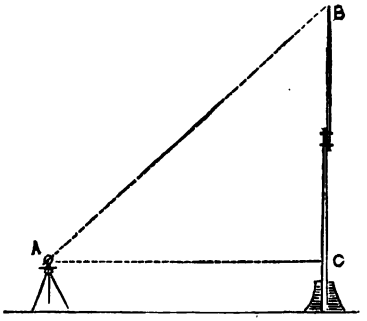



FIG. 47.

## THE THEODOLITE.

**80.** The principles involved in the construction and use of the theodolite do not differ essentially from those of the transit, above described. In American practice it is rarely used, having been displaced by the lighter, more convenient, and equally accurate, transit. It still holds its place, however, in English practice, and we give a figure of it. As seen from Fig. 48, it is supported on a tripod and tripod-head. For measuring horizontal angles it is provided with a horizontal circle, graduated to degrees and fractions of a degree, and read by two verniers. The vernier-plate, verniers, clamp and tangent-screws, spirit-levels, and standards, do not differ from those already described as belonging to the transit.

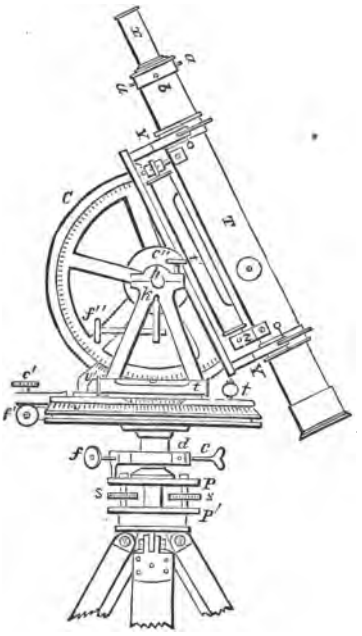


FIG. 48.

The vertical limb consists of a half-circle, C, graduated like the horizontal circle, and read by the vernier, $v'$.

The telescope, T, is supported by two supports, YY, and from their shape called wyes. Collars and pins serve to hold the telescope in its supports. A spirit-level, $t'$, is attached to the telescope to indicate when it is horizontal.

The principal difference between the theodolite and the transit is, that in the former the supports of the telescope are shorter and do not permit the telescope to be revolved entirely over on its axis. Instead of this, however, by unclasping the collars which hold the telescope in the wyes, we may lift the telescope out of its supports and replace it in a reversed position.

The measurements of both horizontal and vertical angles are executed in precisely the same manner in both, and the directions do not need to be here repeated.

## ADJUSTMENTS OF THE THEODOLITE.

**81.** The **adjustment** of the levels on the horizontal limb, and of the vertical limb, is executed in the same way as explained for the transit. But since the telescope cannot be reversed by revolving on its axis as in the transit, the adjustment of the line of collimation must be made in a different way.

**82. To adjust the line of collimation.** Level the horizontal limb, and point the telescope so that the intersection of the threads shall fall

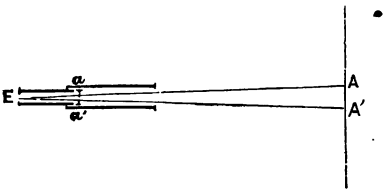



FIG. 49.

upon some distinct distant object, A, in the figure. If now the intersection of the threads is precisely in the axis of the telescope-tube, when the tube is revolved over in the wyes the intersection of the threads will still remain pointed upon the same object, A. If, however, the intersection of the threads be out of this line, as at *a*, when the telescope is revolved over in the wyes, the point *a* will fall as far on the one side of the true axis, at *a'*, as it was before on the opposite, at *a*. Hence, if the line of intersection before pointed to A, it will now point to a different one, A'. It is plain that the intersection of the threads ought to be so changed that it will point to a spot which should be exactly half-way between the two points A and A'. The same test will also determine whether the intersection of the threads is too high or too low in the tube.

The adjustment is made by means of small screws shown in the figure of the theodolite at *a a b b*. By loosening one of these and tightening the opposite, the ring which carries the threads may be moved in any direction, until the test shows it to be correct.

**83. To adjust the standards, so that the axis of the telescope shall be parallel to the plane of the levels.**

Set up the instrument and level it. Hang up near it a long plumb-line, so protected that it shall not be disturbed by the wind. Point the intersection of the threads upon the plumb-line near the top. Revolve the tel-

escope down along the plumb-line; if it follows it precisely the standards must be in adjustment; if it diverges off on one side, the standard on that side is too high.

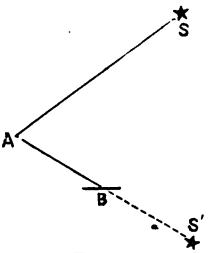



FIG. 50.

A more exact test will be afforded by pointing the telescope at some distant elevated object, as a star, and then at the reflection of the same object in the surface of a fluid at rest. A plate of mercury at B, Fig. 50, is the best for this purpose. From the known principles of optics the point A, the star S, and its reflection S', are all in the same vertical plane. Hence, when revolved down, the intersection of the threads of the telescope must point at the image S' in the surface of the fluid, and any deviation must be corrected by adjusting the standards.

# CHAPTER IV.

## INACCESSIBLE DISTANCES.

**84.** ONE of the principal objects in surveying is to obtain, by indirect measurement, the length of lines which cannot be measured directly. Thus, by the measurement of certain lines and angles, it is possible to obtain the distance across an impassable river, the altitude of a mountain above a horizontal plane, or the distance apart of two inaccessible mountain-peaks. Since the lines whose length is thus sought are commonly distances on a horizontal plane, or the altitude of points above a horizontal plane, the questions arising under this head may be termed **problems of heights and distances.**

**85.** The practical solution of all such problems is effected by two distinct processes:

1. The measurement of the necessary lines and angles.

2. The computation, from these measured lines and angles, of the unknown lines and angles which are required.

Trigonometry teaches what parts of a triangle are necessary to be known to enable us to find the remaining parts, and also explains the methods by which these computations may be made. From these principles it will be seen that in order to find the unknown parts of a triangle it will be necessary to measure

1. One side and two angles.
2. Two sides and the included angle.
3. Two sides and any other angle; or,
4. The three sides.

By means of the methods of trigonometry, therefore, we may solve the following problems, which are those most frequently met with by the surveyor in his practice.

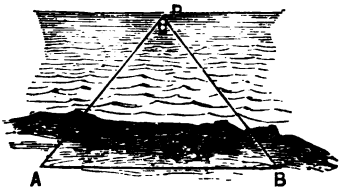


FIG. 51.

**86. Problem I. To determine the distance of an inaccessible point.**

Let P be a point whose distance from A is desired. Measure a base-line, AB, in some convenient direction, and measure with the transit or com-

pass the angles PAB and PBA. These are sufficient to solve the triangle and obtain the distance AP. As a test of the accuracy of the measurement of the angles, it is desirable, when practicable, to measure also the angle P. In a plane triangle the sum of the three angles must equal 180°.

Hence $$P = 180° - (A + B)$$

and by Theorem III., Plane Triangles, we have

$$\sin P : \sin B :: AB : AP = \frac{AB \times \sin B}{\sin P}$$

EXAMPLE.—Desiring to know the distance to an enemy's battery, an engineer measured a base-line, AB, 250 yards, and at its extremities the angle A, 68° 44′, and the angle B, 84° 17′. Required the distance AP.

By the formula $$AP = \frac{AB \times \sin B}{\sin P}$$

$$P = 180° - (A + B) = 180° - 153° 1′ = 26° 59′$$

$$\begin{aligned} \text{Log } AB &= 2.397940 \\ + \log \sin B &= 9.997835 \\ - \log \sin P &= 9.656799 \\ \hline \log AP &= 2.738976 \\ AP &= 548.25 \end{aligned}$$

EXAMPLE.—A surveyor, desiring to ascertain the distance across a river, measured a base-line, AB, 178 yards, and at A measured an angle between the base and a point, P, opposite, 90°; at B he measured an angle 58° 30′. Required the distance AP. *Ans.*

**87. Problem II. To determine the distance apart of two objects separated by an impassable barrier.**

Let A and B be two points whose distance from each other cannot be directly measured. Select some point, P, from which both points may be seen. Measure the angle APB, and the distances BP ($= a$) and AP ($= b$).

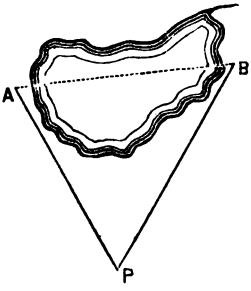


FIG. 52.

From Theorem IV., Plane Triangles, we have

$$a + b : a - b :: \tan \tfrac{1}{2}(A + B) : \tan \tfrac{1}{2}(A - B),$$

in which $A + B = 180° - P$

This proportion, when solved, will give $\frac{1}{2}(A - B)$. Add together half the sum of

A and B, and half their difference, the result will be the greater of the two angles; subtract the same quantities, the result will be the less. Then, by Theorem III., we have

$$\sin A : \sin P :: a : AB = \frac{a \times \sin P}{\sin A}$$

EXAMPLE.—In order to obtain the distance, AB, across a swamp, a surveyor measured at a point, P, an angle, APB, 64° 19′, and the distances PA, 1048.3 yards, and PB, 848.7 yards.

$B + A = 180° - P = 115° 41'$ $\quad \frac{1}{2}(B + A) = 57° 50' 30''$

$b + a = 1897.0$ $\quad b - a = 199.6$

log $(b + a)$..... 3.278067
: log $(b - a)$..... 2.300161
:: log tan $\frac{1}{2}(B + A)$.....10.201544

: log tan $\frac{1}{2}(B - A)$..... 9.223638

$\frac{1}{2}(B - A) = 9° 30' 2''$

$A = 48° 20' 28''$

log sin A.....9.873387
: log sin P.....9.954823
:: log $a$.....2.928754

: log AB.....3.010190

$AB = 1023.61$. *Ans.*

EXAMPLE.—For the purpose of determining the distance, AB, through a group of buildings, a surveyor measured an angle, P, 60°, and the distances PA 4.48 chains, and PB 5 chains. *Ans.* AB = 5.314.

**88. Problem III. To determine the distance apart of two inaccessible objects.**

Let P and Q be two objects which are inaccessible from each other and from the station of the observer. On some convenient ground measure a base-line AB, and at its extremities measure the angles PAQ, QAB, and ABP, PBQ. To compute PQ proceed as follows:

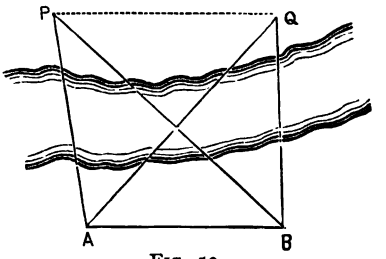


FIG. 53.

1. In the triangle ABP compute AP (Theorem III.).

2. In the triangle ABQ compute AQ (Theorem III.).

3. In the triangle APQ compute PQ (Theorems III. and IV.).

EXAMPLE.—A traveller wishes to determine the distance from himself and from each other of two headlands, P and Q. He measures a base-line, AB, 1000 yards, and the angles PAQ 21° 36′, PAB 78° 11′, ABP 71° 30′, and ABQ 95° 41′.

1. In the triangle ABP, AB = 1000 yards, PAB = 78° 11′, ABP = 71° 30′, APB = 30° 19′.

Therefore,

log sin P.....9.7031011
: log sin B.....9.9769566
:: log AB.....3.0000000
: log AP.....3.2738555

AP = 1878.69

2. In the triangle ABQ, AB = 1000 yards, QAB = 56° 35′, ABQ = 95° 41′, AQB = 26° 44′.

Therefore,

log sin Q.....9.6215871
: log sin B.....9.9978599
:: log AB.....3.0000000
: log AQ.....3.3762728

AQ = 2378.33

3. In the triangle APQ, AP = 1878.69, AQ = 2378.33, PAQ = 21° 36′.

Hence AQ + AP = 4257.02, AQ − AP = 499.64, ½(P + Q) = 79° 12′.

log (AQ + AP)..... 3.6291057
: log (AQ − AP)..... 2.6986572
:: log tan ½(P + Q) .....10.7195122
: log tan ½(P − Q) ..... 9.7890637

½(P − Q) = 31° 36′ 9″

log sin P.....9.9707234
: log sin A....9.5659948
:: log AQ.....3.3762728
: log PQ.....2.9715442

PQ = 936.57

hence P = 110° 48′ 9″
and Q = 47° 35′ 51″

EXAMPLE.—A surveyor wishes to ascertain the distance apart of two islands in a lake. For this purpose he measures a base-line, AB, 500 yards, and the angles PAQ 58° 15′, PAB 93° 48′, ABP 46° 30′, ABQ 120°. Required the distance. *Ans.* 1113.72.

**89. Problem IV. To determine the distance apart of two inaccessible objects, when no point can be occupied from which both can be seen.**

Let P and Q be two points whose distance apart is required. Measure the distance between two points, A and B, from one of which P may be seen, and from the other, Q. Measure also a line AD to a point from which P and A can be seen; and a line BC to a point from which Q and B may be seen. Measure the following angles, PDA, DAP, PAB, and ABQ, QBC, BCQ. The computation may then be made as follows:

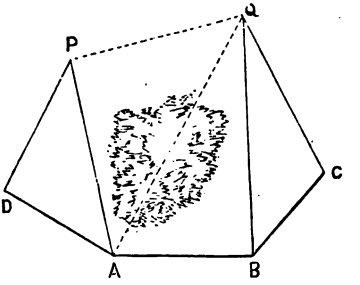


FIG. 54.

1. In the triangle ADP compute AP (Theorem III.).
2. In the triangle BCQ compute BQ (Theorem III.).
3. In the triangle ABQ compute AQ (Theorems IV. and III.).
4. In the triangle APQ compute PQ (Theorems IV. and III.).

EXAMPLE.—To determine the distance apart of two spires, P and Q, a surveyor measured a base-line, AB, 600 yards, and two auxiliary lines, AD and BC, each 500 yards. At the extremities of these lines he measured the following angles: PDA 109°, DAP 44° 30′, PAB 99° 30′, ABQ 103° 20′, QBC 46° 45′, BCQ 101° 50′. Required PQ. *Ans.*

**90. Problem V. To determine the distance of a point from three objects whose distances from each other are known.**

This problem is one of frequent occurrence in maritime surveying, for the location on charts and maps of rocks, reefs, buoys, etc. A number of points are first surveyed on the shore and mapped down in their proper location on the chart. The surveyor then occupies any point whose position is desired, and with a transit (or sextant, when the observations must be made from a boat) measures the angles formed by lines to any three known points. These two angles, together with the known distances of the points from each other, are sufficient to determine the position of the point.

MATHEMATICAL SOLUTION.

Let P be a point whose distances from three points, A, B, and C, are required, the mutual distances of A, B, and C being known. At the point

P measure the angles APB and BPC. Suppose the circumference of a circle constructed which shall pass through P, A, and C. It will intersect the line PB in some point D. Join AD and DC. The angles APB and ACD, being both angles inscribed in the same segment, are equal; in like manner the angles BPC and DAC are equal. The computation may then be conducted as follows:

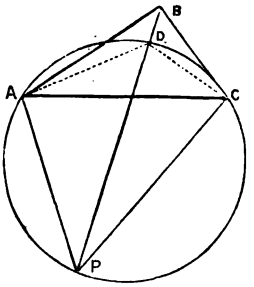


FIG. 55.

1. In the triangle DAC compute DC (Theorem III.).

2. In the triangle ABC compute the angle ACB (Theorem V.).

Then,

$$BCD = ACB - ACD.$$

3. In the triangle BCD compute the angle CBD (Theorem IV.).

4. In the triangle PBC compute PB and PC (Theorem III.).

5. In the triangle APB compute AP (Theorem III.).

It may happen in this problem that the point P is located on the same side of AC with the point B, instead of the opposite side as in the figure; or the point P may be located within the triangle formed by the lines AB, AC, and BC; or the circumference of the circle may cut the line PB in a point beyond B. In each of these cases the same solution will apply, provided that the proper changes are made in the signs of the quantities employed.

GRAPHICAL SOLUTION.

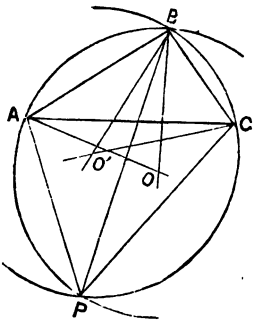


FIG. 56.

**91.** When it is required to locate the point P on a map or chart on which the points A, B, and C are already located, a graphical solution only is required, and may conveniently be executed as follows:

Let A, B, C, be the three fixed points, already plotted in their true position on the chart. Let the angles measured at the point P be APB 20° and BPC 30°. Since an angle at the centre of a circle is twice as great as an angle at the circumference, including the same arc, the angle at O, in Fig. 56, must be twice the angle APB, that is, 40°; and since the tri-

angle AOB is isosceles, the angles at its base must each be $\frac{1}{2}(180° - O)$. Hence, draw at A and B two lines, making with AB angles each equal to 70°; they will intersect each other at some point O. With O as a centre, and a radius AO or BO, describe a circumference; it must pass through the point P. In the same way construct angles at B and C, each equal to 60°, giving the point O'. With this centre and O'B as radius, describe a circumference. It must also pass through the point P. Hence the intersection of the two circumferences must give on the chart the location of the point P.

EXAMPLE.—Desiring to know the position of a rock in a harbor, the positions of three points on the shore were ascertained, and their distances found to be, AB = 623.5 yards, AC = 1216 yards, and BC = 836.4 yards. The angles from the point P were also measured, viz., APB = 26° 18′, and BPC = 32° 52′. The point, P, lay on the opposite side of the line AC from B. Required the distances PA, PB, and PC.

*Ans.*

**92. Problem VI. To determine the altitude of a vertical line above a horizontal plane.**

Let PQ be a vertical line whose altitude above the horizontal plane AQ is desired. Measure from the base of the object any convenient distance QA, and at A measure the angle of elevation PAQ. Then, in the right-angled triangle PAQ we can find the side PQ by Theorem II.

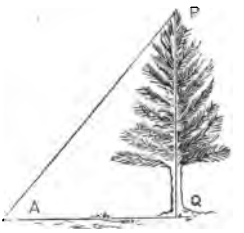


FIG. 57.

In this and the succeeding problems the angles of elevation are measured by an instrument situated above the horizontal surface. The computed result will be the altitude above the level of the instrument, to which must be added in each case the height of the instrument.

EXAMPLES.

1. Required the height of a flag-staff standing on a horizontal plane, the distance QA being 100 feet, and the angle PAQ 68° 45′.

| | |
|---|---|
| R..... | 10.0000000 |
| : tan A..... | 10.4101868 |
| :: AQ..... | 2.0000000 |
| : PQ 257.15..... | 2.4101868 |

2. An explorer, wishing to determine the height of one of the mammoth trees of California, measured from its base 550 feet, and at that

point measured the angle of elevation to its extreme top, 37° 30′. Required its height. *Ans.*

**93. Problem VII. To determine the altitude of an inaccessible object above a horizontal plane.**

Let P be a point whose altitude, PQ, is required. Measure a horizontal line, AB, running directly toward the object, and at the points A and B

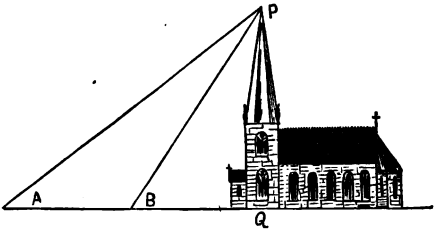



FIG. 58.

measure the angles of elevation PAQ and PBQ. The altitude may then be computed as follows:

$$APB = PBQ - PAQ$$

1. In the triangle ABP compute BP (Theorem III.).
2. In the triangle PBQ compute PQ (Theorem I.).

EXAMPLE.—The altitude of a church spire is required. A line, AB, is measured 100 feet, and the angles PBQ 62° 45′, and PAQ 40°. *Ans.*

*Second Method.*

**94.** When a horizontal line in the direction of the object cannot be obtained, we may proceed thus:

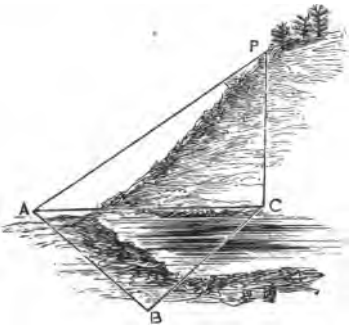



FIG. 59.

Measure a base-line, AB, in any direction. If the ground is not horizontal on which it is measured, the horizontal distance between A and B must be measured. At A and B measure the horizontal angles CAB and CBA, and also at one of the points the vertical angle PAC. Then,

1. In the triangle CAB compute AC (Theorem III.).

2. In the triangle PAC compute PC (Theorem II.).

EXAMPLE.—To find the height of a precipice, a surveyor measured a base-line, AB, 250 feet, and the angles CBA 73° 15′, CAB 59° 48′, and the angle PAC 48° 56′. *Ans.*

**95. Problem VIII. To determine the altitude of an object situated on an inaccessible elevated point.**

Let PQ be an object whose height above the elevation, Q, is required. Measure a base-line, AB, directly toward the object. Measure the angles of elevation QAR, PAR, and PBR. The height of PQ can then be computed thus:

1. In the triangle ABP compute AP (Theorem III.).

2. In the triangle PQA compute PQ (Theorem III.) in which

$$PAQ = PAR - QAR$$

and $$AQP = 90° + QAR$$

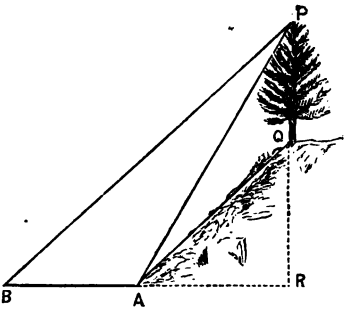



FIG. 60.

EXAMPLE.—A surveyor, wishing to ascertain the height of a tall tree standing upon the top of an elevation, measured a base-line, AB, 600 feet, and the angles QAR 34° 10′, PAR 45° 45′, and PBR 31°. Required the height PQ. *Ans.*

MISCELLANEOUS EXAMPLES.

1. Having measured a distance of 200 feet in a direct horizontal line from the bottom of a steeple, the angle of elevation of its top, taken at that point, was found to be 47° 30′. Required the height. *Ans.* 218.26 feet.

2. Wanting to know the distance between two trees situated on a plain, in a straight line from the bottom of a tower 120 feet high, I measured the angles of depression to each from the top of the tower, to the nearest 64° 30′, and to the most distant 33°. Required the distance between the trees. *Ans.* 173.66 feet.

3. To get the distance across a river, a surveyor measured 200 yards along the shore, and the horizontal angles 68° 2′ and 73° 15′, at the extremities of the line, to a house on the opposite shore. Required the distances to the house. *Ans.* 296.54 yards and 306.19 yards.

4. To determine the distance of a fort from two ships of war, the vessels sail directly from each other 440 yards. The horizontal angle at each, between the other and the fort, is then measured, viz., 83° 45′ and 85° 15′. Required the distances from the fort to each vessel.

*Ans.* 2292.26 yards and 2298.05 yards.

5. Desiring to know the distance between two headlands, I measured from each, to a certain point inland, 735 and 840 yards; also, the horizontal angle included between these lines 55° 40′. What was the distance required? *Ans.* 741.2 yards.

6. There are on shore three points, whose distances I know to be AC 848 yards, AB 426 yards, and BC 524 yards. From a boat off shore I measure the angles, from my position, P, APB 13° 30′, CPB 29° 50′. The point B was observed to lie on the same side of AC as the boat. Required the distances from my position to the three points.

*Ans.* AP 1211.42, BP 859.36, CP 1048.47.

# CHAPTER V.

## AREAS.

**96.** THE **area** of a surface is the number of times it will contain some known unit of area. Thus, a square measuring 10 feet on each side, is said to contain 100 square feet. That is, if a square, measuring one foot on each side, were applied 100 times to the given surface, it would exactly cover it. If the figure ABDC be a rectangle whose length, AB, is 8 feet, and height, AC, 6 feet, it is plain, if we divide the base and height into feet, and draw parallel lines through the points of division, the rectangle will be divided into as many squares of one foot each as the product of the base and the altitude. To find the area of any figure, therefore, as a triangle, parallelogram, or circle, is to determine to what number of units of area its surface is equivalent. From the principles of geometry and trigonometry, rules are deduced for determining the areas of regular figures from their linear dimensions.

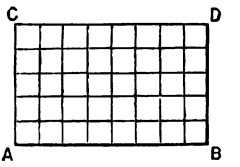


FIG. 61.

**97.** The **units of area** used in surveying are the square foot, the square yard, the square rod, the square chain, the rood, and the acre. All these, except the last two, are squares having sides of a length equal to the linear unit of the same name. These units all bear to each other such simple ratios that they may easily be translated into each other.

The following table shows these ratios:

EQUIVALENT AREAS.

| ACRE. | ROOD. | SQUARE CHAIN. | SQUARE ROD. | SQUARE YARD. | SQUARE FOOT. |
|---|---|---|---|---|---|
| | | | | 1 | 9 |
| | | | 1 | $30\frac{1}{4}$ | $272\frac{1}{4}$ |
| | | 1 | 16 | 484 | 4356 |
| | 1 | $2\frac{1}{2}$ | 40 | 1210 | 10890 |
| 1 | 4 | 10 | 160 | 4840 | 43560 |

**98.** In surveying farm-lands, the area is usually expressed in **acres, roods,** and **square rods.** Thus, a farm in the form of a rectangle, one

side being 34.26 chains, and the other 21.87 chains, will contain 749 acres, 1 rood, 3 square rods.

When small plats of ground are measured, the area is expressed in square feet, or square yards, or square rods.

Ten square chains are exactly equivalent to one acre. Hence, when land has been measured with Gunter's chain, and the lines expressed in chains and links, the area obtained will be expressed in square chains and decimals. From this, the area in acres and decimals may be obtained by dividing by 10. The roods and square rods equivalent to the decimals are obtained by multiplying successively by 4 and by 40.

In Table I. will be found a formula for computing the areas of most regular geometrical figures. From these may be derived rules for solving all problems involving areas in surveying. The solution requires two distinct processes: **first**, the measurement in the field of the necessary lines and angles; and, **second**, the computation from these of the areas required.

**99. Problem I. To determine the area of a rectangular field.** Measure two adjacent sides, and the area is equal to their product.

EXAMPLES.

1. A rectangular field has one side 10.14 chains, and the other 24.46 chains. Required the area in acres, roods, and perches.

*Ans.*

2. A square field measures 11.38 chains on each side. Required the area. *Ans.*

**100. Problem II. To determine the area of a triangular field.**

*First Method.*

Measure one side, and a perpendicular let fall on that side from the opposite angle. Half the product of the two dimensions is the area required.

EXAMPLE.—What is the area of a triangular field whose base is 15.34 chains, and its altitude 6.73 chains? *Ans.*

*Second Method.*

Measure two sides of the triangle, and the angle included between them. The area is equal to half the product of the two sides into the sine of the included angle.

EXAMPLES.

1. Two sides of a triangle are 34.18 chains and 22.16 chains, and the included angle is 53° 30′. Required the area.

$$\text{Area} = \tfrac{1}{2}(34.18 \times 22.16 \times \sin 53° 30')$$

log 17.09.....1.232742
log 22.16.....1.345570
log sin 53° 30′.....9.905179

log area .....2.483491

*Ans.* 304.43.

2. Two sides of a triangular lot were 200 feet and 325 feet, and the included angle was 79° 48′. Required the area. *Ans.*

*Third Method.*

Measure the three sides of the triangle. The area may then be computed as follows:

1. Take half the sum of the three sides.
2. Subtract from the half sum each side separately.
3. Multiply together the half sum and the three remainders.
4. Extract the square root of the product.

This rule may be expressed in the formula:

$$\text{Area} = \sqrt{s\,(s-a)\,(s-b)\,(s-c)}$$

in which $a$, $b$, and $c$ are the three sides, and

$$s = \tfrac{1}{2}(a + b + c)$$

EXAMPLES.

1. Given the three sides of a triangle, 200, 150, and 100 yards. Required the area.

$s = \frac{1}{2}(a + b + c) = 225$; $s - a = 25$; $s - b = 75$; $s - c = 125$.

log $s$.....2.352183
log $(s - a)$.....1.397940
log $(s - b)$.....1.875061
log $(s - c)$.....2.096910

2)7.722094

3.861047

*Ans.* 7261.85.

2. What is the area of a triangular field whose sides are 25.69, 49, and 50.25 chains? *Ans.* 61 acres, 1 rood, 39 perches.

**101. Problem III. To determine the area of a field in the form of a parallelogram.**

*First Method.*

Measure one of the parallel sides and a perpendicular let fall on that side from the opposite. The area is equal to the product of the two measurements.

EXAMPLES.

1. The base and altitude of a parallelogram were measured, 40 rods and 4 rods. Required its area in acres. *Ans.*

2. How many square feet of plank will cover the roadway of a skew-bridge whose length is 218 feet 6 inches, and its perpendicular width 22 feet 6 inches? *Ans.*

*Second Method.*

Measure two adjacent sides of the parallelogram and the angle between them. The area is then equal to the product of the two sides into the sine of the included angle.

EXAMPLE.—A plat of ground in the form of a parallelogram is 228 feet and 140 feet on its two sides, and their included angle is 75° 15′. Required the area. *Ans.* 30868.3 square feet.

**102. Problem IV. To determine the area of a trapezoid.**

Measure the length of the two parallel sides and a perpendicular between them. The area is equal to the product of half the sum of the parallel sides by the perpendicular. Or,

$$\text{Area} = p \times \frac{a + b}{2}$$

in which $a$ and $b$ are the two sides, and $p$ the perpendicular.

EXAMPLE.—The two parallel sides of a trapezoid are 5.42 chains and 7.89 chains, and the perpendicular 4.34 chains. Required the area. *Ans.*

**103. Problem V. To determine the area of any quadrilateral figure.**

Measure the two diagonals and the angle which they make with each other. Then

$$\text{Area} = \tfrac{1}{2}ab \sin A$$

in which $a$ and $b$ are the diagonals, and A the angle made by them. Since the angle A′ is the supplement of the angle A, and the sines of both are equal, we may measure whichever angle is most convenient.

EXAMPLE.—In a quadrilateral field there were measured the diagonals 9.48 chains and 6.78 chains, and the included angle 98° 56′. Required the area. *Ans.*

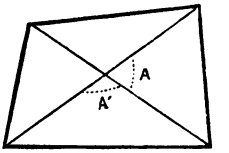



FIG. 62.

**104. Problem VI. To determine the area of any figure bounded by straight lines.**

Let ABCDE, etc., be any figure bounded by straight lines. Divide the field into triangles by diagonal lines in any convenient manner. Measure the lines and angles necessary to determine the areas of these triangles by either of the methods explained. The sum of the triangles must be equal to the area of the figure required. Thus, let the diagonals d, d′, d″, etc., and the perpendiculars p, p′, p″, etc., as shown in the figure, be measured. Then

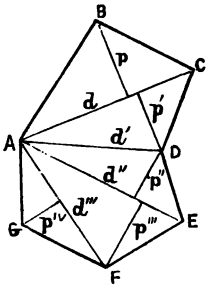



FIG. 63.

$$\text{Area} = \tfrac{1}{2}(pd + p'd + p''d'' + p'''d'' + p^{IV}d''')$$

EXAMPLE.—Wishing to ascertain the area of a field bounded by five sides, a surveyor measured the sides AB 4.24 chains, AE 5.10 chains, and the diagonals AC 11.36 chains and AD 11.09 chains; also,

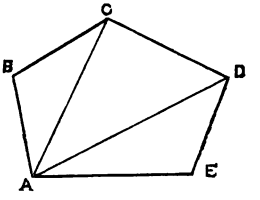



FIG. 64.

the angles BAC 46° 48′, CAD 30° 50′, and DAE 38° 15′. Required the area. *Ans.*

**105. Problem VII. To determine the area of a piece of ground bounded on one or more of its sides by an irregular line.**

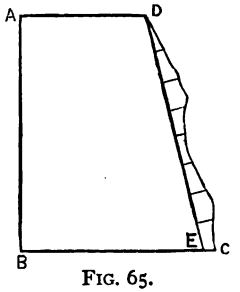


FIG. 65.

Let ABCD be a figure in which DC, one of its boundary-lines, is irregular. Run a straight line, DE, agreeing as nearly as convenient, with the irregular line. At convenient intervals along this line, measure, perpendicular to it, offsets to the irregular line.

Compute the area of the regular figure, ABED, by the usual rules. Compute the area of the small figures between the offsets on the hypothesis that they are triangles and trapezoids. If these areas are without the regular figure, add them; if within, subtract them.

If the offsets are measured at equal intervals, the area of the whole irregular part may be obtained by the following rule:

RULE.—Add together the intermediate offsets and half the extreme offsets, and multiply the sum by the interval between the offsets.

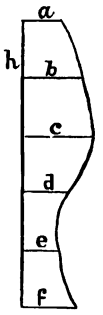


FIG. 66.

This rule will be evident from the following demonstration:

$$\text{First trapezoid} = h\left(\frac{a}{2} + \frac{b}{2}\right)$$

$$\text{Second trapezoid} = h\left(\frac{b}{2} + \frac{c}{2}\right)$$

$$\text{Third trapezoid} = h\left(\frac{c}{2} + \frac{d}{2}\right)$$

$$\text{Fourth trapezoid} = h\left(\frac{d}{2} + \frac{e}{2}\right)$$

$$\text{Fifth trapezoid} = h\left(\frac{e}{2} + \frac{f}{2}\right)$$

Hence, $$\text{whole area} = h\left(\frac{a}{2} + b + c + d + e + \frac{f}{2}\right)$$

# CHAPTER VI.

## SUVREYING WITH THE COMPASS.

**106.** The **surveyor's compass**, described in Chapter III., furnishes one of the most valuable methods of surveying land. Although deficient in accuracy, the simplicity and rapidity of the field-operations with the compass give it great advantages when great precision is not required. Nearly all the early surveys in the United States have been made with the compass, and the necessity which constantly arises for the surveyor to trace out old boundary-lines, and to settle the location and contents of lands described in old title-deeds, renders a thorough knowledge of the practice of compass-surveying essential to the land-surveyor.

**107.** In compass-surveying the directions of the boundary-lines are all referred to the **magnetic meridian**, as indicated by the direction of the magnetic needle. The magnetic needle makes an angle with the true north and south line, which is called the declination or variation of the needle. The laws of this variation will be discussed in the succeeding chapter. The relative direction of the boundary-lines, or the area of plots of ground, will not differ, whether referred to the true meridian or to the magnetic meridian.

**108.** The **bearing** of a line or course is the angle which that line makes with the meridian. MAB, in Fig. 67, is the bearing of the course AB. The **reverse bearing** is the angle which the course, BA, makes with the meridian at B, that is, ABS'. Since the meridians passing through points not far distant are parallel, the bearing and reverse bearing of a course must be equal.

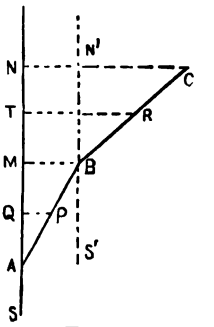


FIG. 67.

The bearing of a course is denominated north-east when it runs to the east of the meridian and north of an east and west line; northwest when it runs west of the meridian and north of the east and west line, etc.

**109.** The **difference of latitude** of a course is the distance by which its second extremity is farther north or south than the first. For brevity

this is usually called the **latitude** of the course. It is called a northing if the course runs northward, and a southing if southward. AM is the latitude of the course AB, and is a northing; BN′ is the latitude of the course BC.

The **departure** of a course is the distance by which its second extremity is farther from a given meridian than the first. It is called an easting if the course runs eastward, and a westing if westward. MB is the departure of the course AB, and N′C of the course BC, both being eastings.

The **meridian distance** of a point is the distance of that point from a meridian. MB and N′C are the meridian distances of the points B and C respectively. The meridian distance of a line is the distance of its middle point from a meridian. PQ and RT are respectively the meridian distances of the lines AB and BC from the meridian NS.

**110.** From the right-angled triangle ABM, we have

$$AM = AB \times \cos MAB$$
$$BM = AB \times \sin MAB$$

That is, for any course

$$\text{The latitude} = \text{distance} \times \cos \text{bearing}$$
$$\text{The departure} = \text{distance} \times \sin \text{bearing}$$

From these formulæ the latitude and departure for any course may be computed.

Look out in a table of natural sines and cosines, the cosine and sine corresponding to the given bearing.

Multiply these numbers respectively by the length of the course. The first will give the latitude, the second the departure.

Thus, required the latitude and departure of a course whose distance is 11.25 chains, and bearing 38° 45′.

$$\text{The latitude} = 11.25 \times \cos 38° 45′ = 8.7737$$
$$\text{The departure} = 11.25 \times \sin 38° 45′ = 7.0416$$

**111. A traverse table** is a table of latitudes and departures for different distances, and bearings. It is computed from the formulæ above. The traverse table in this work is computed for every quarter of a degree of bearings, and for distances from 1 to 10. Bearings are usually not measured with the compass nearer than quarter degrees. The latitudes and departures for other distances than those given in the table can be obtained by addition and multiplication. Thus, to obtain the latitude and departure for a course whose bearing is N. 44° 30′ W, distance 39.44 chains: under the proper angle we find in the table,

| | | | | | |
|---|---|---|---|---|---|
| For distance | 3, | latitude = | 2.1398, | departure = | .27 |
| ∴ For distance | 30, | latitude = | 21.398, | departure = | 21.027 |
| For distance | 9, | latitude = | 6.419, | departure = | 6.308 |
| For distance | .4, | latitude = | 0.285, | departure = | 0.280 |
| For distance | .04, | latitude = | 0.029, | departure = | 0.028 |
| ∴ For distance | 39.44, | latitude = | 28.131, | departure = | 27.643 |

When greater accuracy is required than a table calculated to quarter degrees will furnish, the table of natural sines and cosines may be used. This table may indeed be regarded as a traverse table in which the cosines give the latitudes and the sines the departures for a distance 1. For any other distance we multiply the latitudes and departures by the given distance.

**112.** Let ABCDE, Fig. 68, represent a piece of ground bounded by straight lines whose distances have been measured, and whose bearings have each of them been determined by the compass. Let perpendiculars be let fall from the angles upon a meridian, NS, running through the most western angle. A series of triangles and trapezoids will be formed, by combining which the area of the field may be obtained.

Area = C'CDD' + D'DEE' − (ABB' + B'BCC' + AEE')

By inspecting this formula it will be found that the area of the field is the difference between the sum of the triangles and trapezoids constructed on those sides running north, and those constructed on the sides running south.

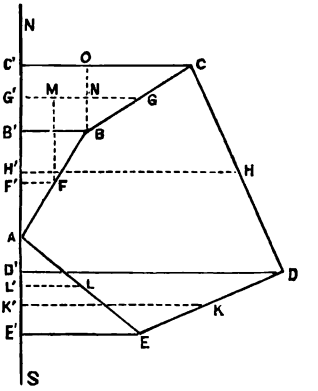



FIG. 68.

**113.** To determine the areas of the several triangles and trapezoids which enter this formula, we proceed thus:

Let perpendiculars be drawn from the middle points of all the courses upon the meridian NS. These will constitute the meridian distances (M. D.) of the sides of the field. Twice these lines will be the **double meridian distances** (D. M. D.) of the sides.

2 × area of ABB' = AB' × 2FF' = latitude of AB × (D. M. D.)
2 × area of B'BCC' = B'C' × 2GG' = latitude of BC × (D. M. D.)
2 × area of C'CDD' = C'D' × 2HH' = latitude of CD × (D. M. D.)
etc. etc. etc.

The triangle or trapezoid, therefore, constructed on any side, has for its double area the product of the latitude of that side multiplied by its double meridian distance.

The double meridian distance is used in this computation instead of the meridian distance, because the method of deriving the former can be expressed in a simpler rule than the latter.

**114.** From the figure it is apparent that 2FF′ is equivalent to BB′. That is, the double meridian distance of the first course is equal to its departure. Again,

$$GG' = G'M + MN + NG.$$
$$GG' = (\text{M. D.}) \text{ of AB} + \tfrac{1}{2}\text{dep. of AB} + \tfrac{1}{2}\text{dep. BC.}$$
$$2GG' = (\text{D. M. D.}) \text{ of AB} + \text{dep. of AB} + \text{dep. BC.}$$

That is, the double meridian distance of the second course is equal to the double meridian distance of the first course + the departure of the first course + the departure of the second course.

By similar reasoning we could show that—

The double meridian distance of any course is equal to the double meridian distance of the preceding course + the departure of the preceding course + the departure of the course itself.

Having now found the double meridian distances of the several courses, the areas of the several triangles and trapezoids can be computed by article 113; and by combining these in the formula of article 112, the area of the whole figure may be found.

**115.** The most convenient mode of combining all these operations may be summed up in the following rule, recording the successive results in a table:

| STA. | DIS. | BEARING. | LATITUDES. | | DEPARTURES. | | D. M. D. | N. AREAS. | S. AREAS. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | E. | W. | | | |
| | | | | | | | | | |

1. Measure the sides of the field and their bearings, and record them in the columns headed distance and bearing.

2. Seek out in the traverse table the latitudes and departures of each course, and record them in the appropriate columns, according as they are north or south, east or west.

3. Compute the double meridian distance of each course, and record it in the column headed D. M. D., remembering that—

The double meridian distance of the first course is equal to its departure:

The double meridian distance of the second course is equal to the double meridian distance of the first course + the departure of the first course + the departure of the second course;

The double meridian distance of any course is equal to the double meridian distance of the preceding course + the departure of the preceding course + the departure of the course itself.

In adding for double meridian distances, the departures to the east are to be treated as positive, and those to the west as negative. If worked correctly, the double meridian distance of the last course will be equal to its departure.

4. Multiply the quantities in column D. M. D. by those in columns N. and S. of latitude, and place the products in the corresponding columns of areas.

5. Sum up the areas in the columns N. and S., and half the difference between them will be the area required.

## FIELD-WORK OF COMPASS-SURVEYING.

**116.** From the preceding discussion of the theory of a compass-survey it will be plain that the field-work must consist in measuring the lengths and bearings of the boundary-lines, and of such other lines whose locations and dimensions we desire to ascertain. It will best be understood from an example.

Begin at any prominent corner of the farm, as A, Fig. 69, and measure the distance and bearing of each side successively. It is immaterial in which direction the surveyor proceeds, but the explanation which follows is formed on the supposition that he goes round the farm keeping it on his right hand.

**117.** The **distances** are measured with the chain, as explained in Chapter II. A signal is established at stations B, C, etc., toward which the chainmen direct their measurement. Sometimes the real line to be measured is occupied by a wall or hedge, and cannot be followed with the chain. In this case, set off on one side, by signals placed at equal distances from the two ends, a line which is parallel and equal to the real line, and free from obstruction.

In measuring the sides, the surveyor notes, not only the lengths of the sides, but also the distances to any noteworthy objects, as the crossing of the small stream from the spring, by the course CD, etc. Prominent objects near the line are sometimes determined by measuring from some point in the line, as the distance of the bridge from the corner B.

**118.** The **bearing** of the line AB is determined by placing the compass directly over the point A and sighting toward a signal at B. In this case he finds the line bears by the needle S. 73° 15′ E. A signal is then left at A and the compass moved to B. It is sighted back toward A and the reverse bearing read. The **direct** and **reverse** bearing ought to agree. If the disagreement is small, it may be considered as resulting from the imperfection of the instrument, and the mean between the two taken as the true reading. If the disagreement is considerable, it indicates either

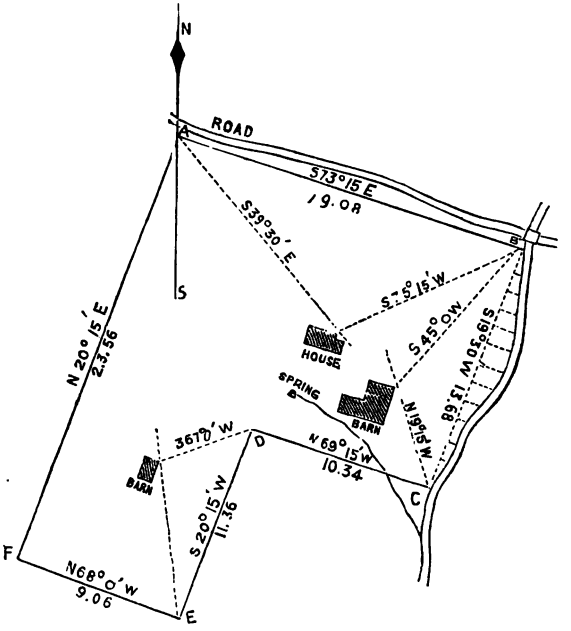



FIG. 69.

an error in the measurement, or some disturbance of the needle caused by the attraction of iron. The error in measurement can be remedied by a second trial. The fact of the local attraction will be shown by an irreconcilable difference between the direct and reverse bearing. The station at which the local attraction causes the error will be that one at

which the reverse bearing on the preceding station and the direct bearing on the succeeding station are both irreconcilable. In this case, the bearings must be assumed to be those which are found at the unaffected ends of the lines.

When the line is occupied by a fence or other obstructions, the compass may be set at any convenient distance from the true line, and sighted at a signal set at the same distance from the other end of the line. The bearing of this parallel must be the same as that of the true line. The compass may be placed also at any point on the line, as well as at its extremity.

**119.** If there are prominent objects on either side of the line whose position it is desired to fix, the bearings of lines running to these from any two stations must also be measured. Thus, the bearings of the lines from the two stations, A and B, to the house, will determine its position. It would be sufficient to measure the bearing of one such line, provided its distance also is measured.

**120.** The surveyor must keep a **record** of the bearings and distances which are measured, and also of any other points noted in the course of the survey. The following table will show the mode of keeping such a record. An additional record of the offsets and of the bearings upon prominent objects must also be kept.

| STA. | DIS. | BEARING. | REMARKS. |
|---|---|---|---|
| A | 19.08 | S. 73° 15′ E. | Along road. |
| B | 13.68 | S. 19° 30′ W. | Offsets to stream. |
| C | 10.34 | N. 69° 15′ W. | 1.11 crosses small rivulet. |
| D | 11.36 | S. 20° 15′ W. | |
| E | 9.06 | N. 68° 0′ W. | |
| F | 23.56 | N. 20° 15′ E. | |

**121.** Since in many surveys much detail must be recorded concerning offsets, and intersection of streams, fences, etc., a mode of keeping field-notes, represented in Fig. 70, is preferable.

Draw in the middle of a page of the note-book two parallel lines. These may be considered as representing the continuous boundary-line of the farm, split into two, so that the distances may be recorded between them.

Begin at the bottom of the page, in order that the line in the note-book, when held in front of the face, may correspond in position to the

line in the field. Insert between the lines the letter A, representing the first station. To the right set the bearing of the first course.

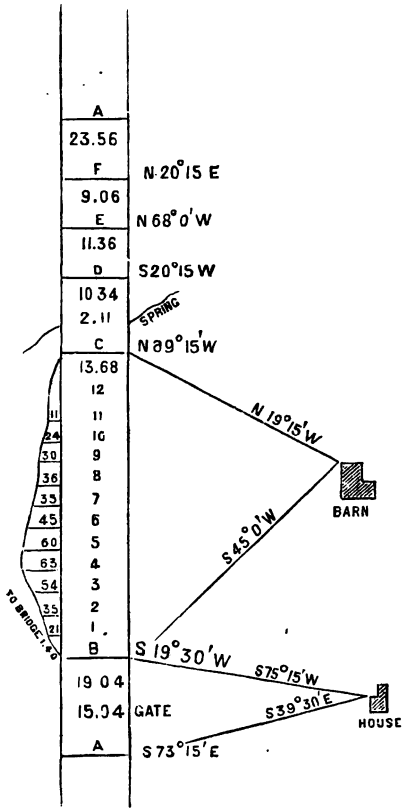



FIG. 70.

If the bearing of any other object from A is taken, as the line to the house, draw the line to the right or left as the object stands, and write on it the observed bearing.

Above A insert the measured distance along the boundary-line to any objects noted, and to the next stations. Thus, 15.94 shows the distance from A to the gate, and 19.04 the distance to B.

To the right at B write the bearing of the next course BC, and also note the bearing of any other line from B; in this case a line from B to the house, and a line from B to the barn.

When offsets are measured from a course, as along BC, mark between the lines the distance from the previous station, and on the proper side record the offsets. In this example the offsets are measured at intervals of one chain, and recorded in links. They are measured by a rod or tape at right angles to the course, the direction of the offsets being determined with sufficient accuracy by eye.

From such a record the surveyor could put down on paper an exact representation of the farm surveyed, and could make the necessary computations for determining the area.

**122.** In making a survey of land, it is important to fix carefully the **position of the corners**, so that they may be readily found subse-

quently. A stone, or a stone monument, or a stake with stones heaped around it, should be placed at the corners, and the location with reference to surrounding objects described in the field-notes of the survey.

If a line runs through timber-land, it is well to mark it by "blazing" the trees lying in or near its direction. These marks on trees remain for many years, and may aid in identifying the line. The names of the surveyor and his assistants should be inserted in the notes of the survey, and in the maps of the land, so that witnesses in regard to the location of the lines may be available at any subsequent date.

## COMPUTATION OF AREA.

**123.** Having finished the field-work of the survey, the next step is to **compute the area.** For this purpose construct a table having twelve vertical columns, and insert in them the stations, distances, bearings, taken from the notes of the survey.

| STA. | BEARING. | DIS. | Latitudes N. | Latitudes S. | Dep'tures E. | Dep'tures W. | Corr'd Lat's. | Corr'd Dep's. | D.M.D | N. AREAS. | S. AREAS. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | S. 73° 15′ E. | 19.08 | | 5.49 | 18.28 | | — 5.52 | +18 31 | 34.67 | | 191.3784 |
| B | S. 19° 30′ W. | 13.68 | | 12.89 | | 4.57 | — 12.91 | — 4.55 | 48 43 | | 625.2113 |
| C | N. 69° 15′ W. | 10.34 | 3.66 | | | 9.67 | + 3.65 | — 9.65 | 34.23 | 124.9395 | |
| D | S. 20° 15′ W. | 11.36 | | 10.66 | | 3.93 | — 10 68 | — 3.91 | 20.67 | | 220.7556 |
| E | N. 68° 0′ W. | 9.06 | 3.39 | | | 8.40 | + 3.38 | — 8.38 | 8.38 | 28.3244 | |
| F | N. 20° 15′ E. | 23.56 | 22.11 | | 8.15 | | + 22.08 | + 8.18 | 8.18 | 180.6144 | |
| | | 87.08 | 29.16 | 29.04 | 26.43 | 26.57 | | | | 333.8783 | 1037.3453 |
| | | | | | | | | | | | 333.8783 |
| | | | | | | | | | | | 2)703.4667 |
| | | | | | | | | | | | 351.7333 |

Error in latitude = .12; error in departure = .14.

Seek out in the traverse table the latitudes and departures of the several courses, and insert them in their appropriate columns. If the survey were absolutely correct, the sum of the northing must be equal to the sum of the southings, and the sum of the eastings to the sum of the westings. With such measurements as can be made with the chain and compass such accuracy cannot be attained. Generally, there is a difference between the northings and southings, called the **error in latitude**; and a difference between the eastings and westings, called the **error in departure.** On the theory that these errors are in proportion to the distances run, the required corrections may be made by the following proportions:

The sum of all the distances : any one course ::
the error in latitude : the correction.

The sum of all the distances : any one course ::
the error in departure : the correction.

These corrections must be added to the latitudes and departures which are too small, and subtracted from those which are too large.

In the above example these proportions will be

87.08 : 19.08 :: .12 : correction for latitude, 1st course, = .026
87.08 : 13.68 :: .12 : correction for latitude, 2d course, = .019
etc.,

87.08 : 19.08 :: .14 : correction for departure, 1st course, = .030
87.08 : 13.68 :: .14 : correction for departure, 2d course, = .022
etc.

In most cases it is not necessary to compute the corrections by these proportions. They may be obtained sufficiently nearly by observing how much the error is for each chain, and then distributing the corrections in proportion to the number of chains.

When the latitudes and departures have been thus corrected, record them in columns of "corrected" latitudes and departures. These ought to balance exactly. In the table of the example given, we have placed the northings and southings in the same column, marking the former + and the latter − ; so also with the eastings and westings.

**124.** Beginning at the most westerly station, in this example at station F, compute the double meridian distances of each course according to the rule given in article 114, and record them in the column D. M. D. It is not absolutely essential to begin at the most westerly station ; any other point of beginning might be used. But our explanation has been based on the supposition that the meridian to which the departures and meridian distances are referred passed through the most western station. This station may be determined by inspecting the notes of the survey, or by constructing a hand-sketch of the field surveyed. Of course, the most western station is not always the station from which the survey began, and which stands first in the notes.

In this example, beginning at F,

D. M. D. of FA = 8.18

To get D. M. D. of AB, we have, by the rule,

D. M. D. of FA = 8.18
Departure of FA = 8.18
Departure of AB = 18.31
D. M. D. of AB = 34.67

To get D. M. D. of BC, we have, by the rule,

| | | |
|---|---|---|
| D. M. D. of AB | = | 34.67 |
| Departure of AB | = | 18.31 |
| Departure of BC | = | − 4.55 |
| D. M. D. of BC | = | 48.43 |

etc.

**125.** The columns of areas are computed by multiplying the number found in the D. M. D. column by the number in the latitude column. If the latitude is north or +, set the product in the column of north or + areas; if south or —, set it in the south or — column.

Add up these two columns and take their difference. Divide this difference by two, and the quotient must be the area in square chains and decimals. Divide by ten, and the area will be in acres and decimals. For our example,

$$\text{Area} = 35.1733.$$

**126.** The area of the part outside of the course BC may be found by the method explained in Problem VII., Chapter V.

$$\text{Area} = h\left(\frac{a}{2} + b + c + d \ldots . \frac{z}{2}\right)$$

$$\text{Area} = 100\left(\frac{o}{2} + 21 + 35 + 54 + 63 + 60 + 45 + 35 + 36 + 30 + 24 + 11 + \frac{o}{2}\right)$$

Area = 41400 square links = 4.1400 square chains = .414 acres.

Whole area = 35.1733 + .414 = 35.5873.

Whole area = 35 acres, 2 roods, 14 perches.

## DRAWING A PLOT.

**127.** The completion of a survey generally includes the construction of a **plot** or map of the land surveyed. This is of value, not only as a representation of the ground, showing its form and natural features, but also as a check upon the accuracy of work. We give here merely the method of making a diagram of the ground.

A plot of a field is a miniature representation of its boundary, and other lines, given in their true proportion and making their proper angle with each other.

**128.** The first step is to determine upon what **scale** the plot shall be drawn; that is, what ratio the lines of the real field shall bear to their

representatives upon the paper. We may, for example, make an inch upon the paper represent a chain upon the ground; that would be called a scale of **1 chain to an inch**. Or we may make an inch represent 2 chains, or 5 chains, or 10 chains. To facilitate the construction of plots, the scales employed for making the drawings have usually a number of small spaces marked off into tenths, such as an inch, a half-inch, a quarter-inch, etc. If one of these is taken to represent a chain, each

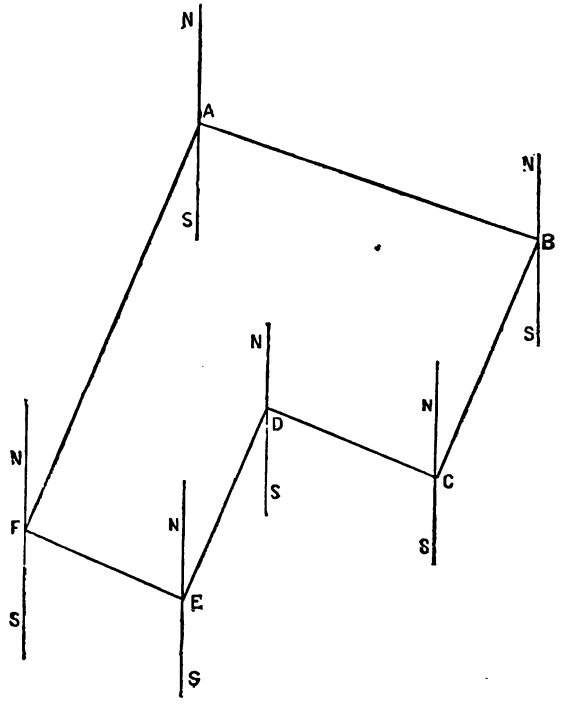



FIG. 71.

tenth would represent ten links. In any particular case the scale to be used must be determined by the dimensions of the ground and the size of the plot which it is proposed to make.

**129.** Having determined upon the scale, select upon the paper some point, A, Fig. 71, as a starting-point, to correspond with the first station of the survey. Through this point draw a straight line, NS, to represent the

direction of the meridian, and with a protractor lay off the direction of the first course; in this case S. 73° 15′ E. Draw an indefinite line in this direction, and on it lay off with the proper scale the length of the first course, 19.08 chains. Mark this point B, the second station in the field. At B draw a line parallel to NS, which will be the meridian at B. From this lay off the bearing of the second course, and draw a line to the same scale, 13.68 chains.

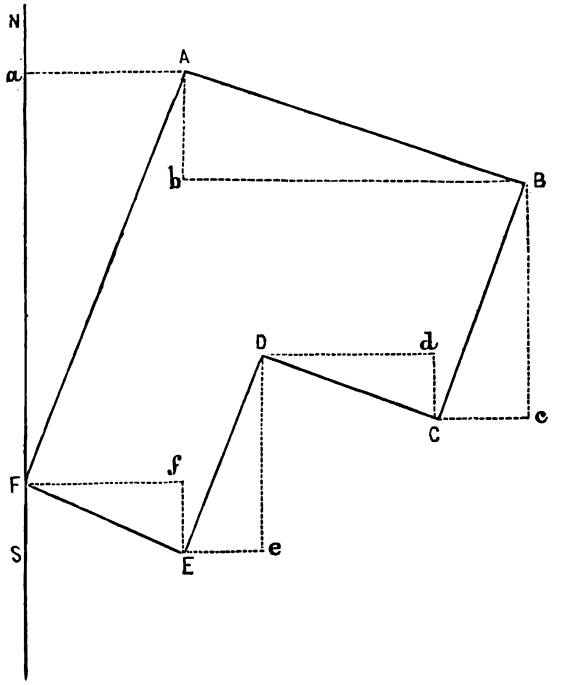



FIG. 72.

At each station draw a meridian, and from it lay off the next course in its given length and direction. The last course should end at the starting-point. Generally, even with the most careful drawing, there will be found a discrepancy. Any very marked discrepancy will show defects in field operations or in making the drawing.

**130.** The above method of plotting employs the bearings and distances as measured in the field, and whatever errors they contained are

followed. By using the latitudes and departures after they have been corrected, we can construct a more accurate plot. Draw at the left side of the paper, Fig. 72, a line, to represent the meridian, through the most western station. Select a point, F, on this line, to represent the most westerly station of the field. Lay off on this line F*a* 22.08 chains, the latitude (north) of the course FA, and perpendicular to this *a*A 8.18 chains, its departure (east). Join F and A; the result will be the true plot of the course FA. At the point A draw A*b* parallel to NS 5.52 chains, the latitude (south) of the course AB; and perpendicular to this *b*B 18.31 chains, its departure (east); and join A and B.

Proceed thus to lay off the latitude and departure of each course; when finally, the latitude and departure of the course FE being measured off, the point of beginning, F, will be reached.

Instead of beginning at F, the most western station, it would be equally easy to begin at A, the first station of the survey.

This method of plotting employs chiefly lines running either north and south, or east and west. By using a drawing-board and a T-square (Art. 5), these lines can be drawn with great facility and correctness.

**131.** After having plotted the boundary-lines of the field, the prominent objects which were observed in the survey may be located by drawing the lines in their proper bearing by which their position in the field was determined.

Thus, to locate the house, draw from A a line bearing S. 39° 30′ E. from the meridian at A, and from B a line bearing S. 75° 15′ W. from the meridian at B; they will intersect at the location of the house on the plot.

The offsets must also be set off along the side BC to the same scale, and an irregular line drawn through their extremities will be the adjacent bank of the stream.

# CHAPTER VII.

## VARIATION OF THE NEEDLE.

**132.** WHEN a small steel bar, which has been carefully balanced so as to hang horizontally, is magnetized, it assumes a position which makes an angle both with the horizon and with the meridian. The angle which it makes with a horizontal line is called the **dip** or **inclination** of the needle. In the United States the north end of the needle dips downward. In the surveyor's compass, to overcome this **dip**, a small counterpoise is placed on the south end.

The angle which the magnetic needle makes with the true meridian, at any place, is called its **declination**, or more commonly its **variation**. When the north end of the needle lies on the east side of the meridian, it is called east variation; when upon the west side, west variation.

**133.** In the United States the needle varies both east and west; in the eastern portion, varying to the west; and in the western portion, varying to the east. A line drawn through those places where the needle varies neither east nor west, is called **a line of no variation**. Such a line runs through the United States in a northwest and southeast direction, passing through Michigan, Lake Erie, near Cleveland, through the eastern part of Ohio, and through the Virginias and North Carolina. In all places east of this line the variation is west, and in all places west of it the variation is east; the amount of variation increasing as we recede from this line in either direction. In the extreme eastern part of Maine the variation is 18° west, and in the State of Oregon it is more than 20° east.

**134.** The accompanying **chart**, Fig. 73, is copied by permission from the Report of the United States Coast Survey for 1865, and represents the lines of equal variation for a part of the United States. It was compiled by Charles A. Schott, from numerous data, and reduced to the epoch of 1870, according to the known rates of change which the variation undergoes. The surveyor can, by inspecting this chart, readily determine within small limits the variation of the needle at any place for 1870. Then, by applying a correction for the annual change, he can determine the variation for any preceding or subsequent year.

**135.** Observations continued through a series of years, at any place, show a continual change to be going on in the variation of the needle.

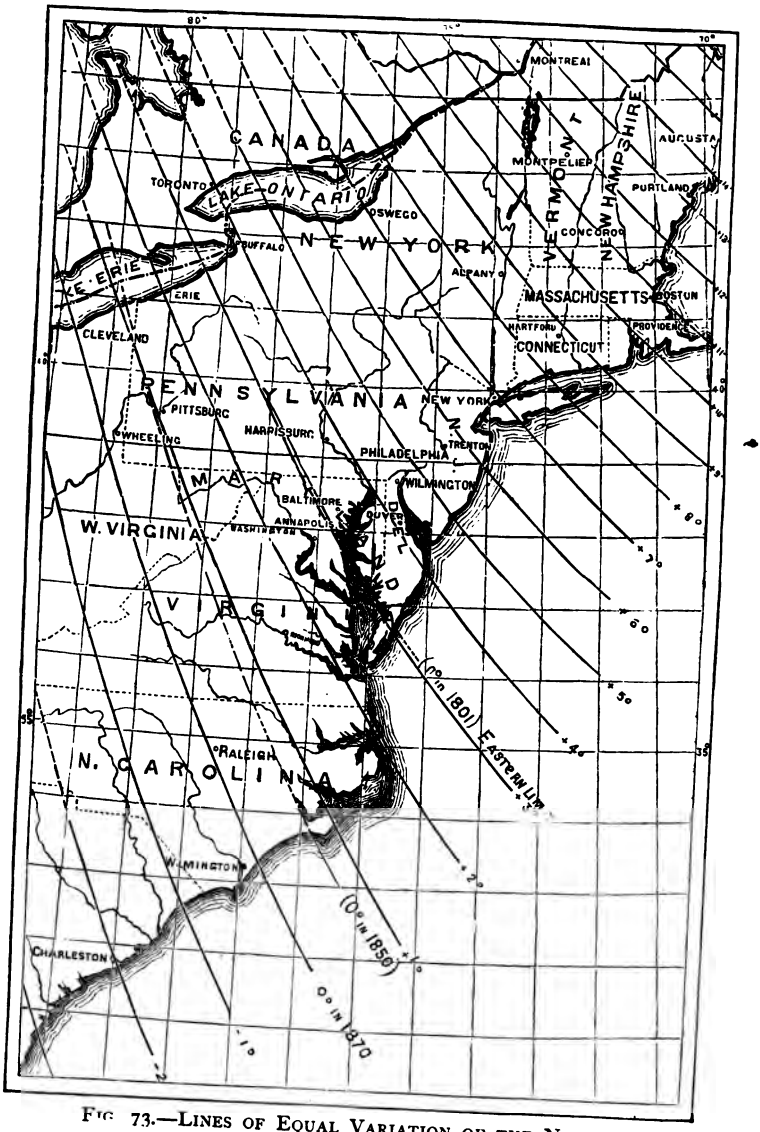



FIG. 73.—LINES OF EQUAL VARIATION OF THE NEEDLE.

At the present time this change consists in a steady **annual movement of the needle** to the westward; so that on the east side of the line of no variation, the variation has been increasing, and on the west side decreasing. An examination of the oldest records in regard to changes in the variation of the needle, indicate that from about 1670 to 1795, the needle changed eastward annually; but from about 1795, the annual change has been westward. This would indicate an oscillatory motion of the needle, requiring about 125 years to complete one oscillation. If this be true, the present annual movement westward will continue till about A.D. 1920, when it will be reversed, and continue eastward.

**136.** The table given below, shows the annual changes of variation for a number of places in the eastern portion of the United States. It is taken from the United States Coast Survey for 1865, from a chart prepared by Charles A. Schott, and gives the annual changes between 1860 and 1870. It will be approximately true for several years to come.

WESTWARD ANNUAL CHANGE FROM 1860 TO 1870.

| PLACE. | ANNUAL CHANGE. | PLACE. | ANNUAL CHANGE. |
|---|---|---|---|
| Albany, N. Y. | 3'.9 | Key West, Fa. | 3'.0 |
| Baltimore, Md. | 3 .4 | Mobile, Ala. | 1 .1 |
| Bath, N. Y. | 3 .6 | New Haven, Ct. | 4 .7 |
| Boston, Mass. | 3 .7 | New Orleans, La. | 0 .2 |
| Buffalo, N. Y. | 3 .6 | New York, N. Y. | 3 .8 |
| Burlington, Vt. | 4 .5 | Oxford, N. Y. | 4 .9 |
| Cairo, Ill. | 2 .0 | Portland, Me. | 3 .2 |
| Charleston, S. C. | 2 .0 | Providence, R. I. | 3 .0 |
| Eastport, Me. | 1 .6 | Quebec, Can. | 5 .5 |
| Erie, Pa. | 3 .0 | Rutland, Vt. | 5 .7 |
| Harrisburg, Pa. | 1 .5 | Savannah, Ga. | 1 .8 |
| Hartford, Ct. | 4 .6 | Washington, D. C. | 3 .1 |
| Havana, Cuba. | 1 .3 | Williamsburgh, Va. | 3 .7 |

**137.** If curves were drawn on a chart through those points in the eastern part of the United States included in the above table, which have the same annual change, we should find that:

The curve of 2' annual change would pass near Eastport, Me., through the Atlantic near Charleston and Savannah, through Florida into the Gulf of Mexico.

The curve of 3' would pass near Portland, Me., through Martha's Vine-

yard, through the Atlantic south of Long Island, through southern New Jersey and Maryland into Virginia; thence bending northwest, through Baltimore, through Pennsylvania, and entering Lake Erie between Buffalo and Erie.

The curve of 4′ would pass through New Hampshire, Massachusetts, Connecticut into Long Island Sound, nearly through New York City and Philadelphia; thence bending northward through central Pennsylvania and New York.

The curve of 5′ would pass between Burlington and Rutland, Vt., into New York west of Albany, and in Otsego County, bending northward, and running through northern New York.

**138.** Besides the annual westward change, the needle is subject, also, to **daily fluctuations**, depending apparently upon the movements of the sun. In the northern hemisphere the needle has a westward movement from about 7 or 8 A.M., reaching a maximum of about 10′ to 15′ at 2 P.M., from which time it recedes to its former position. In the summer this diurnal change of variation is greater than in winter.

Slight **disturbances** are also not unfrequently observed in the position of the needle, especially during thunder-storms, auroras, and other electrical phenomena. These, however, do not interfere with the use of the needle in surveying.

**139.** It is evident, from the above facts, that the magnetic needle, although of the utmost value in surveying as well as navigation, must be employed with great caution, in order that the various irregularities to which it is liable may not invalidate the operations depending upon it. In re-running the lines of old surveys, made when the variation of the needle was different from its present variation, we must not expect to find the magnetic bearings correspond until we have made an allowance for the change during the interval. In surveying with the compass in places distant from each other, it is necessary to take into account the difference in the amount of variation prevailing at these places. In making a survey with the compass, it is important that the surveyor should note upon his field-book and upon the map the date of the survey and the variation of the needle prevailing at the time, and see that it is inserted in any deed or conveyance drawn up by him.

To enable the surveyor to determine the variation of the needle, he must be provided with the means of establishing the direction of a true meridian. This is done by observations on the heavenly bodies.

**140.** If the position of the **north pole** of the heavens were exactly marked by a star, by pointing the telescope of the transit or the sights of the compass upon it, we would have the direction of a true north and south line. No star occupies this position, but the north star (Polaris) revolves

around it in a small circle at a distance of about one and a half degrees. It makes the circuit in 23h. 56m. Twice during this interval it crosses the meridian, once above the true pole, at A, Fig. 74, and once below, at B. These are called respectively the upper and lower culminations of the star. An observation on the north star at either of these points would give the direction of a north and south line.

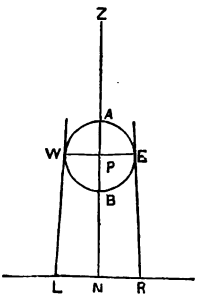


FIG. 74.

Almanacs prepared for the use of astronomers and navigators, such as the British and American Nautical Almanacs, give the time of the upper culminations for each day in the year. The time of the lower culmination will be 11h. 58m. later. Several smaller almanacs give the means of knowing these times with sufficient exactness for the purposes of the surveyor.

**141.** The following table gives the **times of the upper culmination** of the north star for each fifth day. For intermediate days the times may be obtained by interpolation. When the upper culmination occurs in daylight, it is necessary to use the lower culmination instead. The times printed in black-faced type in the table indicate those occurring between 6 P.M. and 6 A.M.

UPPER CULMINATION OF POLARIS, 1872.

| | 1st Day. | 6th Day. | 11th Day. | 16th Day. | 21st Day. | 26th Day. |
|---|---|---|---|---|---|---|
| | H. M. S. | H. M. S. | H. M. S. | H. M. S. | H. M. S. | H. M. S. |
| January.... | **6 29 3** | **6 9 19** | 5 49 35 | 5 29 51 | 5 10 6 | 4 50 22 |
| February... | 4 26 41 | 4 6 57 | 3 47 14 | 3 27 30 | 3 7 47 | 2 48 4 |
| March..... | 2 32 19 | 2 12 36 | 1 52 54 | 1 33 13 | 1 13 31 | 12 49 55 |
| April..... | 12 26 20 | 12 6 49 | 11 47 0 | 11 27 22 | 11 7 43 | 10 48 6 |
| May..... | 10 28 27 | 10 8 51 | 9 49 14 | 9 29 38 | 9 10 1 | 8 50 26 |
| June..... | 8 26 54 | 8 7 19 | 7 47 43 | 7 28 7 | 7 8 33 | 6 48 57 |
| July..... | 6 29 22 | 6 9 47 | **5 50 12** | **5 30 37** | **5 11 1** | **4 51 26** |
| August .... | **4 27 56** | **4 8 20** | **3 48 44** | **3 29 9** | **3 9 32** | **2 49 57** |
| September. | **2 26 24** | **2 6 48** | **1 47 10** | **1 27 33** | **1 7 55** | **12 48 18** |
| October.... | **12 28 38** | **12 9 0** | **11 49 21** | **11 29 41** | **11 10 2** | **10 50 21** |
| November.. | **10 26 45** | **10 7 4** | **9 47 23** | **9 27 41** | **9 8 0** | **8 48 17** |
| December.. | **8 28 35** | **8 8 52** | **7 49 8** | **7 29 25** | **7 9 41** | **6 49 58** |

**142.** Instead of observing the north star at its upper and lower culmination, we may observe it at the points E or W, Fig. 74. These are called its **greatest eastern or western elongation**, respectively. 5h. 59m. before its upper culmination it is at its greatest eastern elongation, and 5h. 59m. after, at its greatest western elongation.

Vertical lines through E and W cut the horizon at R and L to the right

and left of the north point N. When these points are observed, therefore, for determining the meridian, a correction of the amount of LN or RN must be made. This is the azimuth of the star, and may be obtained by the formula,

$$\text{Sin NR} = \frac{\text{sin PE}}{\text{cos PN}} = \frac{\text{sin polar distance}}{\text{cos latitude}}.$$

The polar distance of the star is given in the nautical almanacs. For January 1, 1872, it is 1° 22′ 23″, and changes very slowly. The following are the values of the azimuth for latitudes from 30° to 49°.

AZIMUTH OF POLARIS, 1872.

| LAT. | AZIMUTH. | LAT. | AZIMUTH. | LAT. | AZIMUTH. | LAT. | AZIMUTH. |
|---|---|---|---|---|---|---|---|
| 30° | 1° 35′ 8″ | 35° | 1° 40′ 34″ | 40° | 1° 47′ 33″ | 45° | 1° 56′ 31″ |
| 31 | 1 36 7 | 36 | 1 41 51 | 41 | 1 49 10 | 46 | 1 58 36 |
| 32 | 1 37 9 | 37 | 1 43 9 | 42 | 1 50 52 | 47 | 2 0 48 |
| 33 | 1 38 14 | 38 | 1 44 33 | 43 | 1 52 37 | 48 | 2 3 08 |
| 34 | 1 39 22 | 39 | 1 46 1 | 44 | 1 54 32 | 49 | 2 5 35 |

**143.** The observations for **establishing a meridian** are best made with a transit or theodolite. Select some point where a suitable permanent mark may be left, and directly over this mark place the instrument and level it. Set the vernier at zero and unclamp the lower limb. A few minutes before the expected culmination, or elongation, point the telescope on the star so that the vertical thread covers it. As the star moves away from the thread, follow it by the slow-motion screw attached to the limb. Continue the motion until the exact time arrives. If a culmination is observed, the instrument is exactly north and south, and a second mark may be set by it.

If an elongation is observed, the vertical thread must be made to follow the star, until the star, moving more and more slowly, begins to retrograde. The slow motion of the star at elongation, and the fact that a small error in the time does not affect it, render observations at elongation more easy and more reliable than at culmination.

The amount of the azimuth given in the table in the preceding article being now turned off on the horizontal limb, the telescope will point in the true meridian, and may be used to set a second mark.

In following a star with the telescope of a transit, some mode of making the threads visible must be employed. This is readily done by causing an assistant to hold a light near, but not quite in front of, the object-glass of the telescope. The light thrown into the tube, and reflected by its

sides, is generally sufficient to illuminate the threads. Manufacturers of instruments now provide a contrivance of a mirror and small lamp for this purpose.

**144.** The direction of the meridian may be obtained without a telescope, although less accurately.

To do this, suspend a long plumb-line from some projecting point in a building, and behind it, at a convenient distance, place on a steady support one of the compass sights, or any contrivance furnished with a fine hole, through which to look. Place the sight so that when the eye looks through it, the plumb-line covers the star. As the star moves away from the line in one direction, move the eye and the sight in the other, so as to keep the plumb-line covering the star. When the moment of culmination comes, as given by the table, stop the sight in the position when the star was covered. The sight and the plumb-line give two points in a true meridian, which may be permanently marked.

If the observation is made at an elongation, the star must be followed until it begins to retrograde. The position of the sight and of the plumb-line will be two points in a line varying from the true meridian by the azimuth given in the table. Place the compass on this line and sight along it. Observe the position of the needle, and then turn the compass in the proper direction the amount of the azimuth.

FIG. 75.

**145.** A close approximation to the true meridian may be obtained by observing when the north star is in the same vertical line with the star **Alioth** in the constellation of the Great Bear. If a plumb-line be suspended as in the preceding article, and it be made to follow the north star, when it has revolved into such a position that the plumb-line covers also the star Alioth, as shown in Fig. 75, it also coincides very nearly with the true pole.

At its lower culmination the figure would be inverted, but the same holds true. The above method may be made more accurate by remembering that the north star comes exactly upon the meridian 22 minutes after it has been in the same vertical line with Alioth; so that if, after we

have observed both stars covered by the plumb-line, we wait 22 minutes, and then cover the north star with the plumb-line, the direction will be exact.

**146.** Every surveyor should establish with as much accuracy as his instruments will permit, **a true meridian**, and mark it with permanent marks. With this line he can, whenever desirable, test the variation of the needle, and any changes which it undergoes would be detected.

It would greatly conduce to the reliability of surveys if **standard meridian lines** were established at various accessible points; and surveyors should be required to observe the variation of the needle in their instruments at designated intervals, and to insert in their surveys of land the variation which prevailed at the time. The State of New Jersey some years since authorized the officers of the various counties to secure the establishment at the county seat of each county of a standard meridian line. Many of the counties availed themselves of this authority, and erected stone monuments, giving the true meridian, and generally also the approximate latitude and longitude of the place. Such a system, if extended and improved, would do much to lessen land litigation, and to develop a knowledge of the laws of the variation of the needle.

# CHAPTER VIII.

## SURVEYING WITH THE TRANSIT OR THEODOLITE.

**147. The transit or theodolite** has two advantages over the compass as an instrument for surveying land. **First,** the angles, being read by a vernier, can be read more accurately than is possible with the needle. Instead of quarter degrees, it is easy to read to minutes or less. **Second,** the use of the telescope instead of the ordinary compass sights, enables the surveyor to see the target at longer distances, and to point upon it more precisely. The addition of the telescope to the magnetic compass, which is now made by many manufacturers, remedies the second of these objections to the compass. But it must be remembered that as we cannot read the angles on the compass to less than quarter degrees, there is little advantage in improving the method of pointing beyond the degree of precision which can be attained in reading the angles.

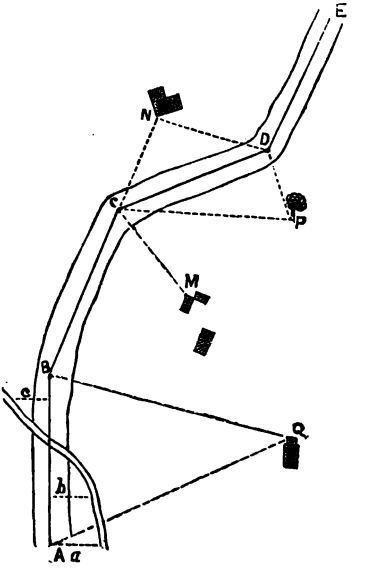



FIG. 76.

**148. To survey a line with the transit.** The line of a road or railroad, or the boundary-line between two estates or townships, has often to be surveyed. Let ABCD, etc., Fig. 76, be a broken line, whose position, directions, and distances are desired. Measure the distances AB, BC, CD, etc., the several parts of the broken line, and with the transit measure the angles ABC, BCD, etc., included between them. Whenever there are objects, as M, N, and P, whose positions are to be fixed, the angles to these objects

from the extremities of one of the lines, or one angle and the distance, must also be measured. Objects near to the line surveyed may be fixed by measuring offsets, as *a*, *b*, and *c*, from the line AB.

The notes for such a survey may best be kept in the method described for compass surveying, Art. 121. Begin at the bottom of the page of the

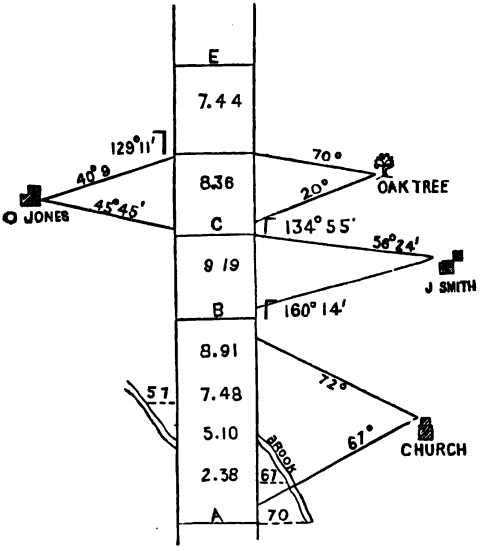



FIG. 77.

note-book, with station A, and record the distances, angles, offsets, etc., as shown in the annexed specimen. The character ⌜ or ⌝ is used to indicate to which side the subsequent line turns.

**149.** For convenience in plotting the survey of such a line, we may, instead of measuring the angles included between the preceding and succeeding line, measure directly from the transit the bearings of all the lines from the first one. Thus, in Fig. 78, set the transit at B, and fix the vernier at zero. Turn the limb so that the telescope shall point to A. Revolve the telescope on its axis: it will now point in the direction BN, with the vernier at zero. Turn the vernier plate till the telescope points at C; the vernier will then give the angle NBC, which may be recorded as the bearing of the line BC with the line AB.

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Clamp the vernier, and remove the instrument to C. Revolve the telescope on its axis, and then point it (the vernier still clamped) back at B. The horizontal limb now stands in the same position in the field as at B, viz., with its zero point in the direction CN'. Clamp the limb. Revolve the telescope back on its axis, and then, unclamping the vernier, point it toward the next station D. The angle indicated by the vernier will be the angle N'CD, which is the bearing of the line CD with CN', or its parallel AB.

Proceeding in this way, we obtain at each station the bearing of the succeeding course with the first course. These angles, when continued from 0° to 360°, measured from the forward end of the line, are called the **azimuth** of the line. In the above example these azimuths would be as follows:

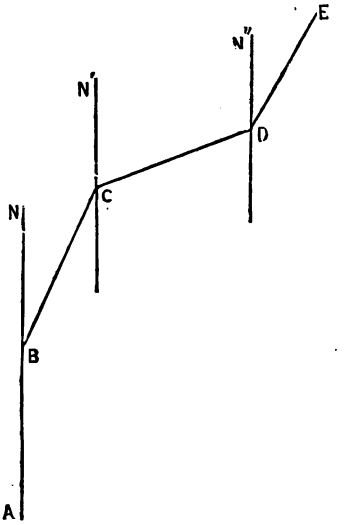



FIG. 78.

| STATIONS. | AZIMUTH WITH AB. |
|---|---|
| A | 0 |
| B | 19° 46′ |
| C | 64 51 |
| D | 14 02 |

**150. The survey of the streets of a city** can best be made with the transit and chain, in the manner above explained. Run the centre line of the street, measuring the distances to each intersection, and at each bend of the street measure the change of direction. Also at the intersections measure the angles made by the cross streets with the one which is run, and measure offsets to the sidewalks, buildings, and other objects, whose position it is required to determine.

Since land under such circumstances is much more valuable than farm-

ing lands, greater care must be exercised, both in measurements of the angles and the distances. The chain should be well tested, and due allowance must be made for slopes. Important distances should be measured in both directions and made to agree. For city surveying, the foot is the most common unit of measure, and hence it is best to use a chain or tape divided into feet.

**151. To survey a tract of land.** For the methods used to determine the areas of tracts of land of regular geometrical form, we refer to the various problems of areas in Chapter V. The general method with the transit consists in dividing the ground into triangles, and measuring the lines and angles, which will suffice to determine the area of each.

When the tract is of such a form that all the angles can be seen from one of the corners, as A, Fig. 79, the simplest process is to place the transit at that point, and measure the angles BAC, CAD, and DAE. Then measure the sides AB and AE, and the diagonals AC and AD, which compose the lines running from the station occupied to the several corners of the field. The area can then be computed by Problem II., Chapter V.

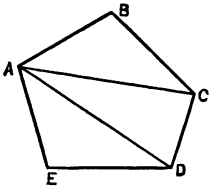



FIG. 79.

**152.** The station occupied by the transit may be chosen within the field when more convenient. The angles at O, Fig. 80, being measured, and the distances OA, OB, etc., we can determine the areas of the triangles, and also the lengths of the sides AB, BC, etc. We have, in this method, a check upon the correctness of the measured angles around O, since their sum, if correctly measured, must be equal to 360°.

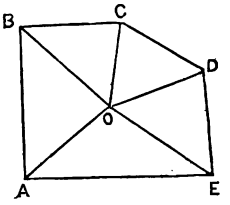



FIG. 80.

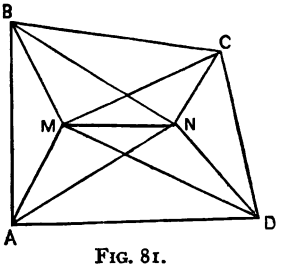



FIG. 81.

Since the measurement of angles can be more correctly made than the measurement of lines, it is obviously advantageous to reduce the measurement of lines as much as possible, and substitute for it the measurement

of angles. This can be done by measuring one line as a **base line**, MN, Fig. 81, and from its extremities measuring the angles to each corner. The base line must be so chosen that from its extremities all the stations can be seen, and its length must not be greatly disproportionate to the sides. It may be selected on the most favorable ground for measurement. One of the sides of the field may be used as a base line; or the base line may be chosen outside as well as inside the field.

The length of MN and two angles being known in each of the triangles, MNA, MNB, etc., the positions of A, B, C, etc., can either be plotted on paper or computed. The area of the entire tract may be computed by finding the area of all the triangles formed by lines radiating from M or N. Thus, MAB, MBC, MCD, and MDA are together equal to the whole figure.

**153.** It is sufficient for determining the figure and area of any tract of land, whatever its shape and dimensions, to **go entirely around it**, measuring the length of its sides, and the angles between the sides. In extended tracts of land, especially those partly covered with timber and otherwise encumbered, this method is almost the only one which can be employed.

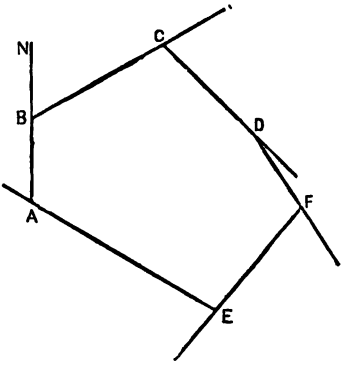



FIG. 82.

Begin at any corner, as A, Fig. 82, and measure the sides, AB, BC, etc. With the transit measure the internal angles ABC, BCD, etc. When one of the angles is re-entrant, the internal angle will be greater than 180°. In traversing the boundary with the transit and the chain, take measurement and note of all objects whose position it is desired to preserve. The measurements will enable us to construct a plot of the tract, and also to compute the area. The field-notes may be kept in precisely the method explained in article 148.

**154.** The following example will illustrate the method of computing the area from the measurement of the sides and internal angles:

| STA. | DISTANCE. | INTERNAL ANGLES. | EXTERNAL ANGLES. | AZIMUTH WITH AB. | BEARING WITH COURSE AB. |
|---|---|---|---|---|---|
| A | 8.93 | 120° 30′ | 59° 30′ | 0 | N. |
| B | 15.64 | 118 30 | 61 30 | 61° 30′ | N. 61° 30′ E. |
| C | 14.27 | 104 45 | 75 15 | 136 45 | S. 43 15 E. |
| D | 8.62 | 170 33 | 9 27 | 146 12 | S. 33 48 E. |
| E | 18.52 | 71 57 | 108 03 | 254 15 | S. 74 15 W. |
| F | 12.18 | 133 45 | 46 15 | 300 30 | N. 59 30 W. |
| A | | | | 360 | |

**Column I.** gives the stations at which the angles were measured.

**Column II.** gives the distance from a station to the next.

**Column III.** gives the internal angles at each station.

**Column IV.** gives the external angle at each station; obtained by subtracting the internal angle from 180°. If the angle were re-entrant this remainder would be negative.

**Column V.** gives the azimuth of each course with the first course, measured from the forward end around toward the right. The azimuth of the first course must be 0. The azimuth of the second course must be equal to the external angle NBC. The azimuth of the third course must be equal to the azimuth of the second course + the external angle between this course and the second. The azimuth of any course will be equal to the azimuth of the preceding course + the external angle of the course itself.

When the angles are all correct, the azimuth of the last course added to the external angle of the first course must make 360°. The excess or deficiency may be distributed equally among the angles, giving the corrected azimuths.

**Column VI.** gives the bearings of the several courses with the first course. They are derived from the azimuths by considering that,

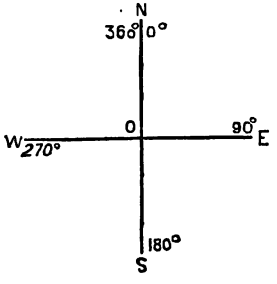



FIG. 83.

**First.** All azimuths between 0° and 90° must lie in the quadrant NOE, and may be marked, as in compass surveying, NE.

**Second.** All azimuths between 90° and 180° lie in the quadrant SOE, and the bearings may be got by subtracting the azimuths from 180°, and marking them SE.

**Third.** All azimuths between 180°

and 270° lie in the quadrant SOW, and the bearings may be got by subtracting 180° from the azimuths, and marking them SW.

**Fourth.** All azimuths between 270° and 360° lie in the quadrant NOW, and the bearings may be got by subtracting the azimuths from 360°, and marking them NW.

**155.** The second and sixth columns of the table may now be treated in the same manner as the distances and bearings in a compass survey.

Arranging the computation as there explained, the above example may be solved as follows:

| STA. | DIS. | BEARING WITH AB. | LATITUDE. | | DEPARTURE. | | D. M. D. | N. AREAS. | S. AREAS. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | E. | W. | | | |
| A | 8.93 | N. | 8.93 | | | | 0 | 0 | |
| B | 15.64 | N. 61° 30′ E. | 7.47 | | 13.74 | | 13.74 | 102.6378 | |
| C | 14.27 | S. 43 15 E. | | 10.40 | 9.78 | | 37.26 | | 387.5040 |
| D | 8.62 | S. 33 48 E. | | 7.15 | 4.80 | | 51.84 | | 370.6560 |
| E | 18.52 | S. 74 15 W. | | 5.03 | | 17.82 | 38.82 | | 195.2646 |
| F | 12.18 | N. 59 30 W. | 6 18 | | | 10.50 | 10 50 | 64.8900 | |
| | | | | | | | | 167.5278 | 953.4246 |
| | | | | | | | | | 167.5278 |
| | | | | | | | Area = 39 acres, 1 rood, 7.17 perches | | 785.8968 |

Since the traverse table does not give the bearings nearer than quarter degrees, it is necessary, generally, in these examples, to use the table of natural sines and cosines. Look out for each bearing the natural cosine, and the natural sine, and multiply them respectively by the distance; the former will give the latitude, and the latter the departure.

The sum of the N. column should be equal to the sum of the S. column, and the E. column to the W. column. The errors in latitude and departure should always be small, and the correction can be made in the same way as in compass surveying. The corrected latitudes and departures may be put in the proper columns. The double meridian distances and areas are computed as in compass surveying. Half the difference between the N. areas and S. areas will give the area of the field in square chains and decimals.

**156.** When it is desired that the position of the tract of land with reference to the true or magnetic meridian should be indicated on the map, it is only necessary that the bearing of any one of the courses with the meridian should be observed, either with the magnetic needle or astronomically. With this the true north and south line can be drawn on the map, and the bearing of any other course with the meridian determined.

### Examples.

1. Given a field, in which AB is 6.60 chains, BC 9.86 chains, CD 7.54 chains, and DA 9.93 chains. The internal angles measured were, A 89° 15′, B 96° 0′, C 84° 30′, D 90° 15′. Required the area.

2. In a six-sided field the following measurements were taken: A 92° 30′, B 94° 30′, C 155° 15′, D 179° 30′, E 94° 15′, and F 104°; also the sides, AB 31.80 chains, BC 2.08, CD 2.21, DE 35.35, EF 20.90, and FA 31.30 chains. Required the area.

# CHAPTER IX.

## LAYING OUT AND DIVIDING LAND.

**157.** THE processes under this head are the reverse of those given in the preceding chapters. It is now required that we find methods for laying out upon the ground, lines and figures whose dimensions are known. In general, it must be left to the skill of the surveyor to devise methods for each particular case. Only a few cases of the most common occurrence are here given, which may serve as models of the methods to be pursued. It is most convenient to arrange them in a series of problems.

**158. Problem I. To lay out a given quantity of land in the form of a square or rectangle.**

In solving this problem it is presumed that the surveyor is limited to start from a given point, and run along some fixed line, as a road, stream, or fence. If the land is to be a square, the side is equal to the square root of the given area. If it is to be a rectangle, of which one side is given, the other side is equal to the area divided by the given side.

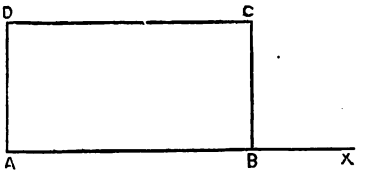


FIG. 84.

Measure off along the fixed line AX, Fig. 83, from the starting-point A, the side of the given square or rectangle. Then at A and B, with the transit, or otherwise, lay off right angles, and measure AD and BC equal to the other dimension.

EXAMPLE.—Lay out along a given line a square containing 5 acres.

Since

$$5 \text{ acres} = 50 \text{ square chains.}$$

$$\text{The side} = \sqrt{50} = 7.071 \text{ chains.}$$

**159. Problem II. To lay out a piece of ground in the form of a parallelogram, the angle between the two sides and the length of one side being given.**

Let it be required to lay off along the lines AX and AY, Fig. 85, a

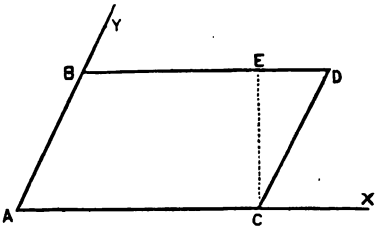



FIG. 85.

parallelogram whose area is $m$, and the side along AX to be equal to $a$.

The area of the parallelogram = AC × AB × sin A.

Hence, $$m = a \times \sin A \times AB$$

$$AB = \frac{m}{a \times \sin A}$$

Hence, measure along AX a line equal to $a$, and along the side AY a line equal to $\frac{m}{a \,.\, \sin A}$, and at the points B and C run lines parallel to AX and AY.

**Otherwise,**

The area of the parallelogram = AC × EC = $a$ × CE

Hence, $$m = a \times CE$$

$$CE = \frac{m}{a}$$

At the point C erect a perpendicular to AC equal to $\frac{m}{a}$, and at E run a line at right-angles to CE meeting AY in B, and make BD equal to AC.

EXAMPLE.—Lay out a parallelogram having an area of 2 acres, along two roads, meeting at an angle of 78° 30′; one side of the parallelogram being 500 feet.

$$AB = \frac{m}{a \,.\, \sin A} = \frac{2 \text{ acres}}{500 \,.\, \sin 78° 30'} = \frac{87120}{500 \,.\, \sin 78° 30'}$$

| | |
|---|---|
| Log 8712 | 3.940118 |
| − Log 50 | 1.699057 |
| − Sin 78° 30′ | 9.991193 |
| Log AB | 2.249868 |

AB = 177.77 feet.

**Problem III. To lay out a given quantity of land when one or more of the boundary lines is an irregular line.**

Required to lay off along a straight line AX, Fig. 85, and an irregular line AY, by a line perpendicular to AX, a quantity of land equal to $m$.

By estimate, assume that a perpendicular from B will cut off the required amount. Make a survey of the field AFGOB, in the usual way, including the offsets. Compute its area, and let it be represented by $n$.

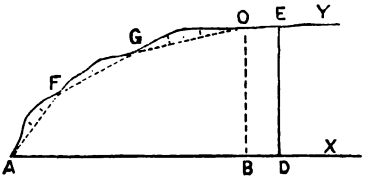



FIG. 86.

$m - n$ = BOED = area to be added to the trial field.

If the boundary OE is nearly parallel to BD, we may find the distance to be added in order to make the required area by the equation

$$\text{BD} = \frac{m - n}{\text{BO}}$$

If BOED is a trapezoid, we must divide, not by BO, but by a mean between BO and DE. This may generally be estimated with sufficient exactness. Hence,

$$\text{BD} = \frac{m - n}{\frac{1}{2}(\text{BO} + \text{DE})}$$

**Problem IV. To lay off a given quantity of land along an irregular line, and along a straight line, when a starting point for the dividing line is assigned.**

Let it be required to lay off a given quantity of land $m$ along the irregular line ABC, Fig. 86, and the straight line AX, by a line CF running from a given point C to some point in AX.

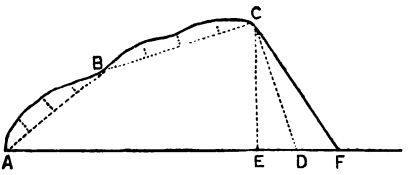



FIG. 87.

Estimate the position of the line cutting off the required amount to be

CD. Survey the field ABCD, including the offsets along AB and BC, and determine its area, and let it be represented by $n$.

$m - n$ = CDF = area to be added to the trial field.

Measure a perpendicular CE drawn from C upon AX.

$$m - n = \text{CDF} = \tfrac{1}{2}\text{CE} \times \text{DF}$$

$$\text{DF} = \frac{m - n}{\tfrac{1}{2}\text{CE}}$$

The perpendicular CE can be got by computation, when in surveying the field the angle CDE was measured.

$$\text{CE} = \text{CD} \times \sin \text{CDE},$$

$$\text{DF} = \frac{m - n}{\tfrac{1}{2}\text{CD} \sin \text{CDE}}$$

**Problem V. To divide a rectangular tract of ground into parts bearing any proportion whatever to each other, by lines perpendicular to one side.**

Let it be required to divide the rectangle ABCD into parts which shall be to each other as $m$, $n$, and $p$, by lines perpendicular to AB. The areas of the several rectangles AEFD, EGHF, and GBCH, into which the ground is to be divided, are to each other as the bases AE, EG, and GB. Hence, it is only necessary to divide the line AB into parts proportional to $m$, $n$, and $p$. That is,

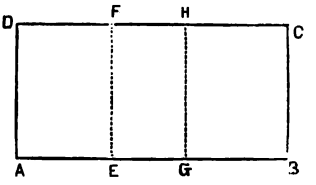


FIG. 88.

$$\text{AE} = \frac{m}{m + n + p} \times \text{AB}$$

$$\text{EG} = \frac{n}{m + n + p} \times \text{AB}$$

$$\text{GB} = \frac{p}{m + n + p} \times \text{AB}$$

EXAMPLE. A rectangular plot of ground was bequeathed to three children. It was 10.24 chains on the side AB, and 4.93 chains on the side AD. It was valued at $1,000, of which the first child was to receive $400, the second $350, and the third $250. Required, the frontage of each along the side AB.

*Ans.* The first received 4.10 chains.
The second received 3.58 chains.
The third received 2.56 chains.

**Problem VI. To divide a triangle by a line running from one angle to the opposite side.**

Let it be required to divide the triangle ABC, Fig. 88, into parts which shall be to each other as $m$ and $n$, by a line running from B to the side AC. Since the triangles ABD and BDC, into which the given triangle must be divided, have the same altitude, they must be to each other as their bases. Hence, it is only necessary to divide the base AC into parts which are to each other as $m$ to $n$.

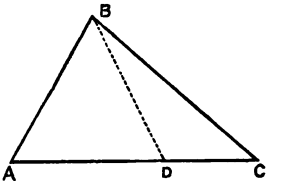



FIG. 88.

$$AD = \frac{m}{m + n} \times AC$$

$$DC = \frac{m + n}{n} \times AC$$

EXAMPLE.—A triangular tract of land containing four acres is to be divided into two parts, which shall be to each other as 5 to 3, by a line running from one of the angles to a side 12.25 chains in length. Required the frontage of each part.

$$Ans.\ AD = \frac{5}{5 + 3} \times 12.25 = 7.66 \text{ chains.}$$

$$DC = \frac{3}{5 + 3} \times 12.25 = 4.59 \text{ chains.}$$

$$\text{Area ABD} = \tfrac{5}{8} \times 4 = 2.5 \text{ acres.}$$

$$\text{Area BDC} = \tfrac{3}{8} \times 4 = 1.5 \text{ acres.}$$

**Problem VII. To divide off from a given tract of land in the form of a triangle, a given part by a line running parallel to one of the sides.**

Let it be required to cut off from the triangular field ABC, Fig. 89, whose area is $m$, a part BDE, whose area is $n$, by a line DE running parallel to AC.

From similar triangles,

$$ABC : BDE :: AB^2 : BD^2$$
$$m : n :: AB^2 : BD^2$$

$$BD = AB \times \sqrt{\frac{n}{m}}$$

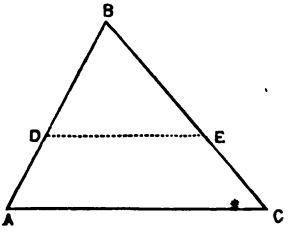



FIG. 89.

In the same way,

$$BE = CB \times \sqrt{\frac{n}{m}}$$

EXAMPLE.—Given a triangular field ABC, containing 5 acres, 2 roods, 20 perches; the side AB 8.64 chains, and the side BC 11.44 chains. It is required to cut off a triangle BDE, containing 2 acres 2 roods, by a line parallel to AC.

$m$ = 5 acres 2 roods 20 perches = 5.625 acres.
$n$ = 2 acres 2 roods = 2.5 acres.

$$BD = 8.64 \sqrt{\frac{2.5}{5.625}} = 5.76 \text{ chains.}$$

$$BE = 11.44 \sqrt{\frac{2.5}{5.625}} = 7.63 \text{ chains.}$$

**Problem VIII. To divide a quadrilateral field into 2 parts having a given proportion to each other by a line starting from a certain point on one side.**

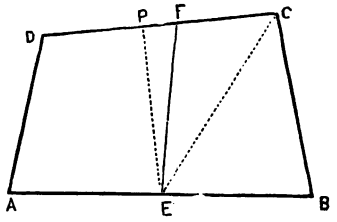



FIG. 90.

Let it be required to divide the quadrilateral ABCD, Fig. 90, into two parts which shall be to each other as $m$ to $n$, by a line starting from E. Let A = area of the quadrilateral.

Then, Area ADFE $= \frac{m}{m+n} \times A$

and, Area FCBE $= \frac{n}{m+n} \times A$

Run a line from the point E to such a corner of the field that the line will divide the land most nearly into the parts required. Let EC be that line. Survey the part ADCE, and compute its area Q. The difference between this area and the area of ADFE will be the amount to be added to or subtracted from ADCE to make the right division.

If, as in the figure, the area ADCE is too great, the portion to be cut off must be a triangle, EFC having an altitude equal to the perpendicular EP, and an area equal to the difference stated. Hence, to find the base CF, we have

$$CF = \frac{ADCE - ADFE}{\frac{1}{2} EP} = \frac{Q - \frac{m}{m+n} A}{\frac{1}{2} EP}$$

In surveying the part ADCE, the angle ECP and the side EC would become known. From these we can compute the perpendicular EP.

$$EP = EC \sin ECP$$

$$CF = \frac{Q - \frac{m}{m+n} A}{\frac{1}{2} EC \sin ECP}$$

**160. Problem IX. To divide any field into two parts having a given proportion to each other, by a line starting from a given point.**

Let it be required to divide the field ABCDEFG, Fig. 91, into two equal parts by a line AM starting from A. Survey the entire field, and determine its area $m$. Suppose a line run from A to some corner D, to cut the field most nearly in the manner required. Compute the area of the part ABCD, and let it be represented by $n$. The difference between this area and half the entire field must be the portion to be subtracted from ABCD to give the required division. In the figure this is a triangle ADM, having a base DM and a perpendicular AP.

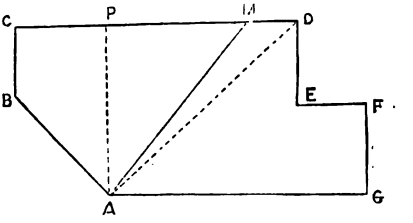



FIG. 91.

$$ADM = n - \tfrac{1}{2} m = \tfrac{1}{2} AP \times DM$$

$$DM = \frac{n - \frac{1}{2} m}{\frac{1}{2} AP}$$

To determine the perpendicular AP, when AD and the angle ADP are known, we have

$$AP = AD \cdot \sin ADP$$

$$DM = \frac{n - \frac{1}{2} m}{\frac{1}{2} AD \cdot \sin ADP}$$

# CHAPTER X.

## UNITED STATES PUBLIC LANDS.

**161.** THE vast territory which from time to time came into the possession of the United States, has all been, as the occasion required, surveyed, and laid out on a uniform system. This system was devised for the purpose of preparing for settlement the lands north of the Ohio River and east of the Mississippi, which had been ceded to the General Government by the States of New York, Virginia, Massachusetts, and Connecticut. It is first distinctly suggested in an ordinance reported by a committee of the old Congress, of which Mr. Jefferson was chairman, on the 7th May, 1784, but was not passed till May 20, 1785. Simeon DeWitt, when the report was presented, was geographer-in-chief of the Continental army, and it is believed that to him the committee owed the essential features of the method of dividing up the public lands, which has been developed into the most perfect system of land partition which has ever been devised. It is, in reality, the same method which was employed by the Roman land surveyors in dividing the conquered territory among the veterans of the army.

**162.** The system consists in dividing the land into equal squares by lines running north and south, east and west. One of these squares, the unit of the entire system, is called a **township**, and is six miles on each side. The township is divided, by lines one mile apart, into 36 **sections**, each of which is one mile square, and contains 640 acres. Each section is again subdivided into quarter sections, containing 160 acres. These townships, sections, and quarter sections are all run out upon the ground and marked by appropriate monuments, and correspondingly numbered upon the government maps.

**163.** This division of a territory into townships rests upon two principal lines, the one running east and west, called the **base line**; the other running north and south, termed the **principal meridian.** In making a survey, these two lines are first run, and the point of their intersection, or **initial point**, is always chosen at some prominent natural landmark, as the confluence of two rivers, or an isolated mountain.

**164.** The position of a township, with reference to these lines, is

designated by its number north or south of the base line, and its number east and west of the principal meridian. Thus, in Fig. 92, the township

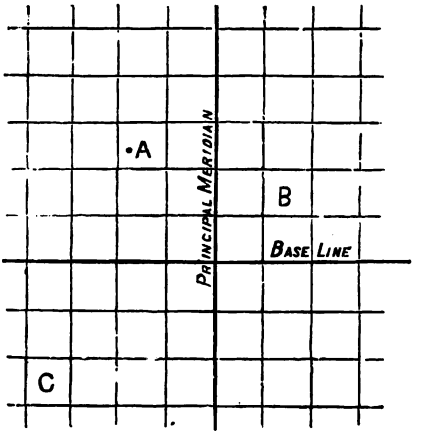



FIG. 92.

marked A would be designated as **township 3 N. range 2 W.**, that is, the third township north of the base line, and in the second range of townships, west of the principal meridian. The township marked B would be termed township 2 N., range 2 E., and that marked C would be township 3 S., range 4 W.

The sections into which a township is divided are designated by num-

| | | | | | |
|---|---|---|---|---|---|
| 6 | 5 | 4 | 3 | 2 | 1 |
| 7 | 8 | 9 | 10 | 11 | 12 |
| 18 | 17 | 16 | 15 | 14 | 13 |
| 19 | 20 | 21 | 22 | 23 | 24 |
| 30 | 29 | 28 | 27 | 26 | 25 |
| 31 | 32 | 33 | 34 | 35 | 36 |

FIG. 93.

bers beginning at the northeast corner, and running westward with the north tier of sections, eastward with the second tier, etc., as shown in Fig. 93.

**165.** Since the meridians in running north converge toward the earth's pole, it is plain they cannot be at the same distance apart at the north and south ends of a township. In latitude 45°, this convergence amounts to 109 feet in six miles. In a system of townships extending over a large territory, this convergence would materially modify the size of the townships and sections. To remedy this defect, it is provided in the government surveys that **standard parallels**, or correction lines, be run

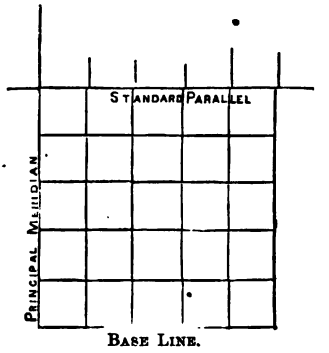



FIG. 94.

(since 1866) every thirty miles north and south of the base line. On these standard parallels the spaces of six miles are measured off anew. Fig. 94 shows how the meridians above and below the standard parallel do not coincide.

**166.** When a new territory is to be surveyed, it must be connected with some territory already surveyed, or a new base line and **principal meridian** established for it. Six **principal meridians** have been established, and are now connected with each other so as to form one continuous system. In addition to these, a number of independent meridians have been established in new territories, and have not yet been connected with the others by intermediate surveys. Thus, in Utah we have the Salt Lake meridian, in Oregon and Washington the Willamette meridian, etc. In the course of the progress of the surveys of the public lands, these independent meridians will all be connected with each other and with the more eastern meridians, thus making a complete network of rectangular townships from the Ohio River to the Pacific Ocean.

**167.** The first step in the survey of a new territory is the selection of an **initial point** from which the base line and principal meridian are to

start. This should be in the neighborhood of the lands whose survey is first desired. The principal meridian must then be run, the township corners and also the corners of the sections and quarter sections being marked upon it. It may extend both north and south of the initial point, and may be continued as the exigencies of the survey demand. The base line and the standard parallels are next run out, in both directions if required, and marked by monuments at the corners of the townships, sections, and quarter sections.

These fundamental lines of the survey must be run with the greatest precision possible. The instrument chiefly relied on is **Burt's solar compass**, a description of which is given in this chapter. The chain used is Gunter's 66 feet chain, and is to be frequently tested by comparison with a standard chain furnished by the Surveyor-General.

**168.** The township lines are always run in the order shown in the annexed diagram, commencing at the corner marked 1, and reaching in regular order the corners 2, 3, 4, etc. The object of this arrangement is

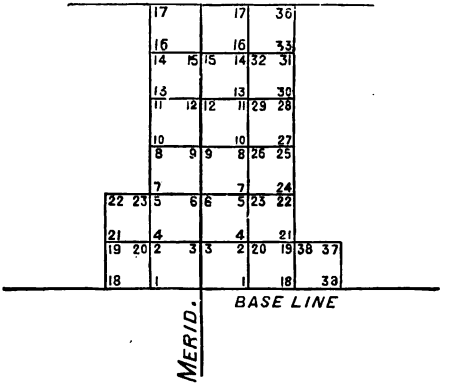



FIG. 95.

to throw all errors and corrections on the north and outside lines of the townships. In running the township lines, the section and quarter section corners are also determined and marked with monuments.

The lines for the sections are run in the same order as directed above for the townships; that is, the surveyor first runs No. 36, then No. 25, etc. Any errors are thus thrown on the upper and outside sections, and cannot extend beyond the next township boundary.

**169.** When a township or other line runs to some impassable barrier, as a river or lake, the surveyor is directed to establish at such point a permanent mark, called a **meander corner**, and then to run along such obstacle a line called a **meander line**. These meander lines determine the form and area of the space reserved from the lands surveyed. All navigable streams, all lakes of more than one mile in length are thus meandered, and reserved in the sale of the public lands.

**170.** The chief object of the Government survey is to establish the corners, and so to designate them that settlers can from them **locate** the lands which they may have purchased. The directions, therefore, issued to the surveyors, specify the mode of **marking the corners** so that they may be identified. The monuments are to be of stone, or of the most durable timbers in the vicinity. They are to be cut of specified figure and dimensions, and to be marked with appropriate devices, so that at any subsequent time it may be known to what township, section, or quarter section a given monument belongs. The meander corners are also to be appropriately marked.

On the standard parallels two sets of corners are required; one set facing the south, being the corners of the northern tier of townships, sections, etc., and one set facing the north, being the corners of the southern tier of townships, sections, etc. The former are called closing township corners, and the latter standard township corners.

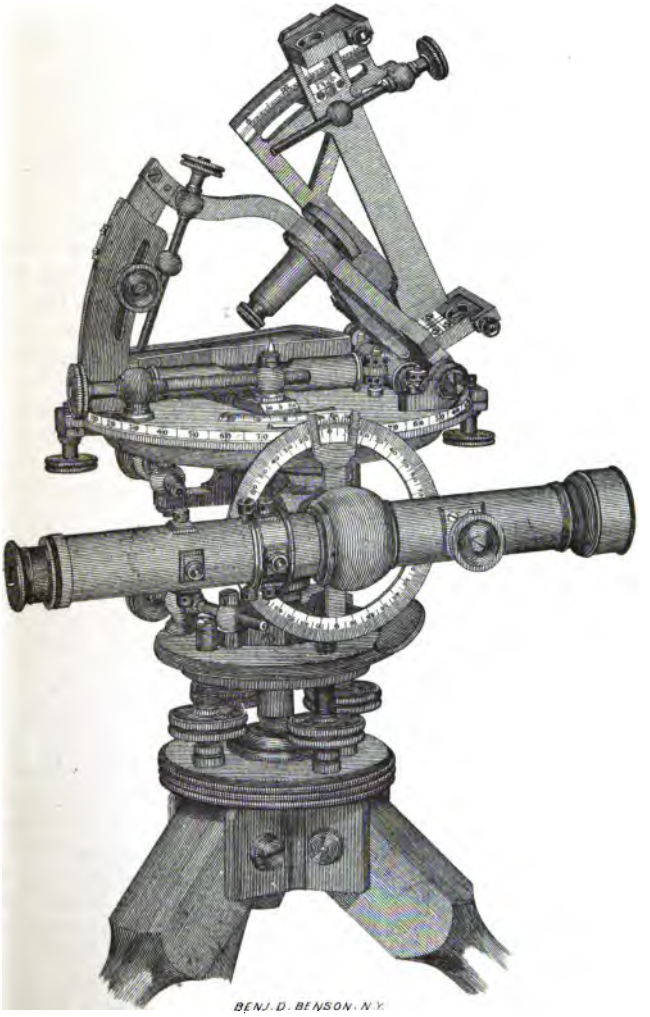
**171.** The surveyor is directed to make accurate note of the features of the land on which his lines are run. All timber lands, swamps, lakes, bayous, etc., are to be noted in his field-books. From these records of the surveys **maps** are constructed, on which the township lines are put down, and all the natural features, with the character of the soil, are indicated.

## SOLAR COMPASS.

**172.** This instrument was invented by William U. Burt, of Michigan, and was patented by him in 1836. It was designed to furnish a ready and accurate method of determining a true meridian, and of running lines with reference to it. It has now come into general use in the surveys of the United States public lands, and in its present most approved form, as now manufactured by Messrs. W. & L. E. Gurley, of Troy, will be here described. The accompanying plate represents the instrument as now constructed by them.

**173.** Its essential parts are three arcs of circles, on which are set off the latitude of the place, the declination of the sun, and the hour of the day, and called respectively the **latitude circle**, the **declination circle**,

# SOLAR TELESCOPE COMPASS,



BENJ. D. BENSON, N.Y.

and the **hour circle.** An examination of the plate will show how these parts are arranged.

The plane of the **latitude circle** is perpendicular to the horizontal limb of the instrument, and is shown in the plate at the left hand. It is connected with a curved bar, which may be called the latitude arm, and which has its centre of motion in two pivots, one of which is shown at the right hand of the figure. It is moved up and down by a tangent-screw, and is provided with a clamp-screw to secure it in any desired position. By means of a vernier it may be read to single minutes. To adapt it to the territory of the United States it has a range from 25° to 60°.

The **declination circle** is shown at the top of the plate, and is so divided as to read to single minutes, through a range of 23° 28′. Its vernier is attached to a straight movable arm, turning on a pivot at its lower end, and is moved by the tangent-screw, and may be clamped in position. The whole circle and its vernier arm are capable of being reversed by turning on an axis, so that the graduated arc may be at the lower end, and its pivot at the elevated end.

The **hour circle** is not shown in the plate, but lies at the right hand. It is used to set off the hour of the day. The middle of the arc is marked 12 o'clock, or 90 degrees. It is graduated on each side of this through an entire range of about 120 degrees, in divisions of half-degrees. The arc forms part of the movable arm of the latitude circle, and at its centre is the **polar axis**, on which the frame of the declination circle turns.

**174.** In addition to these distinguishing features, this instrument has sights like an ordinary compass, or, as in the improved form shown in the plate, has a telescope for more accurate vision; it has level tubes to set the plate horizontal, and it has a magnetic needle poised in a box, shown in the plate at the back of the figure. The needle has a range of about 36 degrees, graduated to half-degrees on an arc numbered from the middle point each way. The needle-box is moved by a projecting arm and a tangent-screw, and is used to set off the variation of the needle east or west.

The **horizontal limb** of the compass is divided so as to read by two opposite verniers to single minutes. The usual clamp and tangent screws serve to adjust this plate in position.

In addition to this, there is provided on the outer rim of the vernier plate a circle divided into parts of 5° or 10°, which may be used to make a rough estimate of any angle which does not require a more precise measurement.

**175.** At each end of the bar of the declination circle is a small convex lens set in a metal plate, having its focus adjusted so as to lie in the surface of the metal plate of the opposite end. Lines are drawn on this plate, two horizontal and two vertical, forming by their intersection a small square,

upon which the image of the sun, when adjusted to the meridian, is thrown. In the position of the instrument as shown in the plate, the image is formed by the lens at the upper end of the arm, upon the plate at its lower end. When the position is reversed, the image is formed by the other lens upon the plate opposite.

**176.** To explain the method of using this instrument, we will suppose, **first**, that the sun is on the equator, as it is on the 21st day of March and the 21st day of September, that is, the sun's declination is zero. **Secondly**, we will assume that it is exactly noon by the sun, that is, that the sun occupies a position precisely south. **Thirdly**, we will assume the latitude of the place occupied is 45°. Proceed as follows:

1. Set the latitude circle at 45°.
2. Set the declination circle at zero.
3. Set the hour circle at 12, the middle point.

It is evident now, that if the plane of the latitude circle of the instrument were set north and south, the plane of the hour circle would coincide with the plane of the equator, the polar axis would point directly to the north pole, and a line through the declination arm would point directly at the sun.

In that case, the sun's rays, passing through the lens at the upper end, would be brought to a focus in the little square on the opposite plate. If the image does not fall directly between the vertical lines which form this square, it would indicate that the instrument is not directed truly north and south, and must be moved right or left until the image is brought into position.

**177.** During the part of the year from March 21st to September 21st, the sun is north of the equator, that is, has north declination. From September 21st to March 21st, it is south of the equator, that is, has south declination. In the former case, the declination circle must be placed as shown in the plate, and then must be set to the proper north declination for the day. In the latter case, the declination circle must be reversed on its axis, and set to the proper south declination. The nautical almanac, which must be used in connection with this instrument, gives the proper declination for noon of each day at Greenwich, that is, for intervals of 24 hours. The change of declination from the noon of Greenwich to the hour of observation at any other place must be taken into account. Fifteen degrees of longitude correspond to one hour of time.

Thus, suppose the observation were made at 2 o'clock, in west longitude 90°. The difference in longitude is equivalent to a difference of 6 hours in time. Hence, the whole time subsequent to the Greenwich noon is 8

hours. The change per hour is given in the almanac, hence it is easy to find the change for 8 hours.

**178.** Assume now that the latitude circle has been set to the proper latitude of the place, and the declination circle set to the declination of the sun for that day, place, and hour.

When the instrument is north, and the polar axis is directed truly to the north pole, and the declination arm set to the sun's declination; by revolving the declination circle on its axis, we could follow the position of the sun in its path from the east to the west, keeping the declination arm constantly pointed toward it. At 6 hours before solar noon the sun would be due east, and when the arm is directed to the sun at that time, the hour angle reads 6; at 4 hours before noon it would read 4, etc. This enables us to use the solar compass at any hour of the day as well as at noon.

When the latitude circle is set, and the declination circle set, and the hour circle set to the proper hour before or after noon by the sun; then, in order that the solar image may be formed by the lens in the declination arm upon its opposite square, **the instrument must be north and south.** Hence, we must move it right or left until the solar image falls in the required place; then we know the instrument to be in the meridian.

**179.** The noon of a good watch or clock does not, in general, coincide with noon by the sun. They differ by an amount which is called the **equation of time**, and which is given for each day in the year in the nautical almanac.

Now, since the hour to be set off on the hour circle of the solar compass is the time before or after noon by the sun, the time given by the watch or clock will require to be corrected by the equation of time, before it can be used for this purpose.

Thus, let the observation about to be made take place at 3h. 18m. 30s. P.M., May 24, 1872. From the nautical almanac for May 24, we find

| | | | |
|---|---|---|---|
| Clock time | = 3 | 18 | 30 |
| Equation of time | = | 3 | 24 |
| Sun time | = 3 | 21 | 54 |

**180.** By the **refraction** of the atmosphere, the rays coming to the eye are slightly bent out of a straight line, so that all objects except those directly overhead appear higher than they really are. At the horizon this effect is greatest, and amounts to about 34′, so that we see the whole discs of the sun and moon above the line of the horizon, when they are still

really below it. In using the solar compass, this displacement of the sun by refraction requires to be taken into account.

The correction requires in all cases to be added to the true altitude, when, as in using the solar compass, we wish to obtain the apparent altitude.

The amount of refraction varies with the altitude, being greatest at the horizon, and zero at the zenith. Tables of refraction are given in the nautical almanacs, and also in manuals of astronomy. For the precise operations of astronomy, the changes produced by variations in the thermometer and barometer require to be taken into account. This is not necessary in surveying. Below is given a table showing the refractions at a mean temperature of 60° Fahr.

TABLE OF REFRACTIONS.

| APPARENT ALTITUDE. | MEAN REFRACTION. | APPARENT ALTITUDE. | MEAN REFRACTION. |
|---|---|---|---|
| 0° 0′ | 34′ 54″ | 11° 0′ | 4′ 49″ |
| 0 20 | 30 52 | 12 0 | 4 25 |
| 0 40 | 27 23 | 13 0 | 4 5 |
| 1 0 | 24 25 | 14 0 | 3 47 |
| 1 30 | 20 51 | 15 0 | 3 32 |
| 2 0 | 18 9 | 20 0 | 2 37 |
| 2 30 | 16 1 | 25 0 | 2 3 |
| 3 0 | 14 15 | 30 0 | 1 40 |
| 3 30 | 12 48 | 35 0 | 1 22 |
| 4 0 | 11 39 | 40 0 | 1 9 |
| 5 0 | 9 47 | 45 0 | 0 58 |
| 6 0 | 8 23 | 50 0 | 0 48 |
| 7 0 | 7 20 | 60 0 | 0 33 |
| 8 0 | 6 30 | 70 0 | 0 21 |
| 9 0 | 5 49 | 80 0 | 0 10 |
| 10 0 | 5 16 | 90 0 | 0 0 |

**181.** The effect of refraction is to increase the north declination of the sun over that given in the nautical almanac, and to decrease the south declination. When the sun is in the meridian the effect of refraction is in the same line with the arcs of declination, and, therefore, the corrections for refraction may be taken directly from the tables of refraction. Take out the declination of the sun for the day, and correct it for the hour and the longitude. Then, if the declination is north, add the refraction; if south, subtract it.

Thus, let the observation about to be taken be in latitude 41° 30′ N., longitude 90° W., at noon of May 24th, 1872.

| | | | | |
|---|---|---|---|---|
| Altitude of equator = 90° − lat. | = | 48° | 30′ | 00″ |
| Declination of sun, Greenwich noon | = + | 20 | 52 | 47 |
| Correction for 90° long. | = + | | 2 | 44 |
| Altitude of sun at observation | = | 69 | 25 | 31 |
| We then have | | | | |
| Correction for refraction | = | | | 21 |
| Declination at observation | = | 20 | 55 | 31 |
| Corrected declination | = | 20 | 55 | 52 |

When the sun is either east or west of the meridian, the refraction, by changing its altitude, does not change its declination by its full amount. Thus, in figure 96, let *s* represent the true position of the sun, *s*D its declination, and ED its hour angle. Let *ss′* represent the effect of refraction upon the altitude; its effect upon the declination would be *sm*, and its effect on the hour angle DD′.

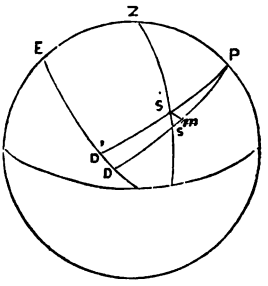


FIG. 96.

The values of *sm* and DD′ for all hours from the meridian, and for different latitudes, have been computed, and are usually given in a table like the following. They are given as fractions of the value of *ss′*, which can be got from the table of refractions. Thus, in latitude 40°, for an observation three hours before or after the meridian, the effect of refraction on declination is $\frac{84}{100}$ of the refraction due to the altitude, and the effect on the hour circle is $\frac{54}{100}$. For example, if the altitude be 70°, we have

| | | | | |
|---|---|---|---|---|
| Refraction due to altitude | | = | 0′ | 21″ |
| Declination component | = .84 | = | 0 | 17.6 |
| Hour component | = .54 | = | 0 | 11.3 |

In ordinary practice with the solar compass, the surveyor, by the aid of lines drawn on the plate, called refraction lines, estimates the effect of refraction, without having recourse to the tables.

PROPORTION OF REFRACTION TO BE ALLOWED IN HUNDREDTHS OF THE WHOLE.

| LAT. | ON DECLINATION ARC. | | | | | | ON THE HOUR ARC. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HOURS FROM THE MERIDIAN. | | | | | | HOURS FROM THE MERIDIAN. | | | | | |
| | 1. | 2. | 3. | 4. | 5. | 6. | 1. | 2. | 3. | 4. | 5. | 6. |
| 30 | 97 | 90 | 79 | 66 | 55 | 50 | 22 | 43 | 61 | 75 | 84 | 87 |
| 32 | 98 | 91 | 80 | 68 | 57 | 53 | 22 | 42 | 60 | 73 | 82 | 85 |
| 34 | 98 | 91 | 81 | 71 | 60 | 56 | 22 | 42 | 59 | 71 | 80 | 83 |
| 36 | 98 | 92 | 82 | 72 | 62 | 59 | 21 | 40 | 57 | 70 | 78 | 81 |
| 38 | 98 | 92 | 83 | 73 | 65 | 62 | 20 | 39 | 56 | 68 | 76 | 79 |
| 40 | 98 | 92 | 84 | 75 | 67 | 64 | 20 | 38 | 54 | 66 | 74 | 77 |
| 42 | 98 | 93 | 85 | 77 | 69 | 67 | 19 | 37 | 53 | 64 | 72 | 74 |
| 44 | 98 | 93 | 86 | 78 | 72 | 69 | 19 | 36 | 51 | 62 | 69 | 72 |
| 46 | 98 | 93 | 87 | 80 | 74 | 72 | 18 | 36 | 49 | 60 | 67 | 69 |
| 48 | 98 | 94 | 88 | 81 | 76 | 74 | 18 | 33 | 46 | 58 | 65 | 67 |
| 50 | 99 | 95 | 89 | 83 | 78 | 77 | 17 | 32 | 45 | 56 | 62 | 64 |

## USE OF THE SOLAR COMPASS.

**182. To determine the latitude of a place.** This requires to be determined frequently in the progress of the surveys—usually every clear day—since the latitude is required in running lines with the solar compass. The observations are best made at noon.

A short time before the anticipated occurrence of the sun noon, set up the instrument and level it. Set off on the declination circle the declination of the sun for that day and longitude, and correction for refraction. Set the hour circle at 12. Then turn the instrument until the solar image falls between the hour lines of the plate, and, by the tangent screw of the latitude circle, bring the image between the equatorial lines. As the time advances toward sun noon, the sun rises higher, and the image will fall below the equatorial lines. Follow the image with the instrument, constantly keeping it between the four lines. When the sun has reached its highest point, at sun noon, its further progress will make the image fall above the equatorial lines. Arrest the movement of the latitude circle at the point when the image ceases to move down, and begins to move up across the equatorial lines.

Read off on the vernier of the latitude circle the arc indicated. It must be the latitude of the place.

**183. To determine the true time by the solar compass.** It is necessary for the surveyor, in running lines, to use the time given by his watch or chronometer. In order that this may be relied upon, he must take frequent occasion to test and correct it.

In observing for latitude, as explained in the last article, the instant when the sun is at its greatest height is the instant of sun noon. Hence, the same observation will serve to determine the latitude and the time. Note the time by the watch or chronometer when the sun is at its meridian altitude. Correct this for the equation of time as given in the nautical almanac for that day. The result will be the reading of the watch or chronometer at true clock noon, and the difference between this and 12 will be the error of the watch or chronometer.

If the instrument is already set north and south, which may be done upon any meridian line, the hour can be determined at any hour as well as noon. Set the latitude and declination circles. Then turn the hour circle until the image of the sun falls truly between the lines. The hour read off on the vernier of the hour circle will be the sun time of the observation. Correct this for the equation of time, and compare with the time of the observation as given by the chronometer. The difference will be the error of the chronometer.

**184. To run lines with the solar compass.** The lines to be run in the government surveys are principally north and south lines or east and west lines. The instrument, however, can be used with equal facility for running any other lines.

**North and south lines.** Set the instrument over the starting-point and level it. Set off the latitude, declination, and hour upon their proper circles, and clamp them fast. Clamp the horizontal limb at zero, and bring the instrument approximately north and south by the magnetic needle. Lastly, by the tangent screw move the horizontal limb till the solar image falls precisely in its position between the lines. The instrument then points north and south, and may be used to locate points in the meridian.

**East and west lines.** Proceed as before, except that the horizontal limb must be clamped, not at zero, but at 90°. The line of sight then stands east and west when the solar apparatus stands north and south.

**Oblique lines.** To determine the bearing of any line with the meridian, set all the circles as before, and turn the telescope in the direction of the required line. Move the solar apparatus until the solar image falls in position. The angle now read on the horizontal limb will be the bearing required.

**185.** The magnetic needle in this instrument is of service to bring it into approximate position, and to run lines when the sun is obscured, or when less precision is required. The meander lines along the banks of rivers and lakes are usually thus run. The section lines, especially when no local attraction disturbs the action of the needle, may be run with the needle alone. But the township lines, and, more particularly, the standard parallels, are all to be run with the solar compass.

Before using the needle, the surveyor determines its variation. This is done by putting the instrument into the meridian by the sun, and then the reading of the needle will be its variation. The needle-box may then be turned by its tangent screw, until the needle reads zero; then the instrument is ready to be used as a vernier compass.

**186.** The telescope in the solar compass, as represented in the preceding plate, is placed at the circumference of the horizontal limb. The displacement of the line of sight from the centre of the instrument may be disregarded in long sights, or by a simple contrivance the target on the target-rod may be set as far out of line as the telescope is displaced.

The use of the telescope on the solar compass enables the surveyor to use the micrometer method of measuring distances, as described in article 43. In crossing rivers, swamps, lakes, and other impediments, this method becomes of the greatest service; its accuracy in skillful hands being almost, if not quite, equal to that of the best chain measurement.

# CHAPTER XI.

## THE PLANE TABLE.

**187.** WHEN the object of the survey is to construct a map of the country surveyed, and not to obtain the dimensions of given lines and tracts of land, an instrument called a plane table has been used with great success. In the United States Coast Survey this instrument is relied on to furnish the details of topography, and under the skillful manipulation of its officers, the construction and use of the table have been carried to a high degree of perfection. We are chiefly indebted to the essay of Lieut. Harrison, published in the United States Coast Survey Report for 1865, for such details concerning its construction and use as we shall here give.

**188.** In the plate annexed, Fig. 97, which is copied by permission from the Coast Survey Report, will be seen the arrangement of a plane table as now employed. It consists of a well-seasoned board, about 24 by 30 inches, and three-fourths of an inch thick. To prevent warping, it is made in two layers, with the grain running in opposite directions.

It is supported on a tripod and tripod-head, and provided with levelling, clamp, and tangent screws, so that it may be levelled, clamped, and adjusted to any position.

The paper on which the map is to be drawn is spread upon the board, and held fast by spring clamps. When the sheet is larger than the board, it may be fastened in a roll under the edge of the board, and as fast as one part of the sheet is filled a new part may be unrolled, and the finished part rolled up. If a small sheet only is required, it may be fastened to the board by drawing-tacks.

**189.** The **alidade** used with the plane table is a brass ruler with bevelled edge, about 20 inches long, from which rises an upright standard bearing a telescope. Instead of the telescope, this ruler is sometimes provided with two upright sights at the ends. The telescope is the same in construction as that used in the transit, and may be provided with a micrometer to measure distances. An arc of a vertical circle attached to the axis of the telescope serves, when required, to measure the angles of elevation or depression of the line of sight. A circular spirit-level is inserted in the brass ruler, which serves to determine when the board is horizontal.

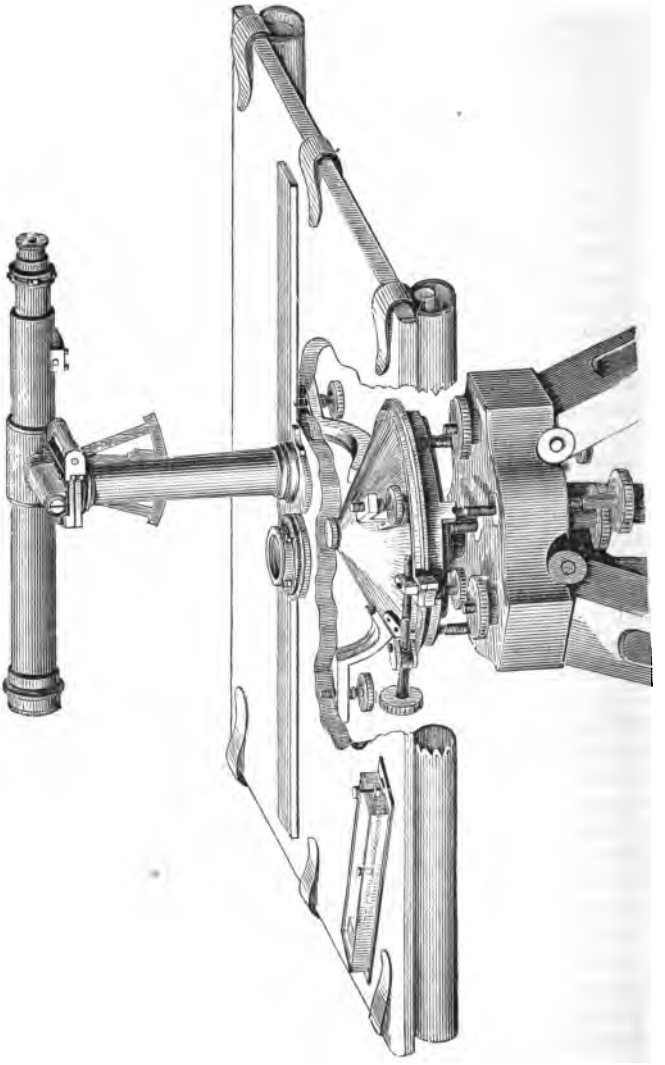


FIG. 97.

A box containing a magnetic needle also accompanies the board. By means of this the magnetic bearing of any line drawn upon the table can be ascertained, and the table itself can be adjusted to any position in the field.

In addition to the apparatus described, the surveyor must be provided with a pair of dividers and a scale, and with pencils and India-rubber. An oil-silk or India-rubber cover should also be at hand to protect the table and instruments from wet and dust.

**190.** The object of the field operations with the plane table is to construct a map or representation of points and lines upon the ground. It is really a drawing-board taken into the field, and as fast as the lines and points are determined they are plotted in their true location and dimensions upon the paper. The location of points in their true position with respect to one another is accomplished by four methods, which, in actual practice, are more or less used in conjunction. These have received the names of the method by **radiation**, the method by **progression**, the method by **prosection**, and the method by **resection**.

**191. By radiation.** Let it be required, for example, to make a map of the field ABCDE, Fig. 98. Set the plane table up at some point in the field from which all the corners of the field can be seen. Bring it to a level by means of the levelling screws, and clamp it fast in position. Point the alidade at each of the stations successively, and draw indefinite lines on the paper from *p*, the point of the paper directly over the point on the ground, toward each of the stations *p*A, *p*B, etc. Measure with the chain, or with the micrometer telescope, the distance from the station occupied by the plane table to each station, and lay off upon the drawer the lines drawn upon the paper, with a suitable scale, these measured distances, *pa*, *pb*, etc. Join the points *a*, *b*, *c*, etc., by straight lines, and the resulting figure *abcde* will be a true representation of the field.

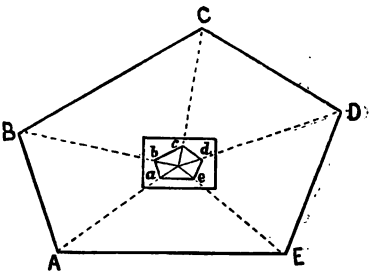


FIG. 98.

The position of any other objects, such as buildings, trees, bridges, etc., may be determined by the same method, by drawing with the alidade a line to each object to be located, and on this laying off to the same scale the measured distance.

When the micrometer telescope can be used for measuring the distances in this method, the operations are exceedingly rapid and easy. And when

extreme accuracy is not required, no way is more convenient for executing a sketch of a tract of ground.

**192. By progression.** In this method the plane table is carried forward and made to occupy successively the stations A, B, C, etc., Fig. 99. Set it up first at station A, and mark some point *a* on the paper to represent A. With the alidade draw through this point *a* an indefinite line directed toward the station B in the field. Measure with the chain or otherwise the distance AB, and lay off this distance *ab* with a suitable scale; *b* will be the location of the point B in the plot.

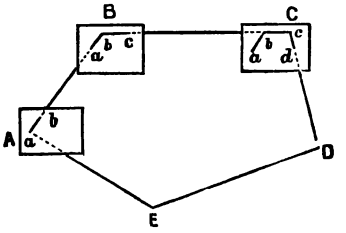



FIG. 99.

Remove the plane table to B. Lay on the alidade so as to coincide with *ba* on the paper, and turn the table to the right or left until the alidade points back at the preceding station A. It is now in exactly the same position with respect to the points of the compass as when at A.

With the alidade draw a line through *b* directed toward C, and on this line lay off the measured distance BC to the same scale as the preceding line; *c* will then be the location of C in the plot. Proceeding thus, we can lay down every station of the field. When we have gone entirely round a field, the last line ought to close with the first station *a*.

**193.** The two preceding methods may often be used conjointly. Thus, in surveying and mapping a road and its adjacent objects, the line of the road itself may be traversed by the plane table, and each of its angles occupied as a station, as in the method of progression. At the same time, by the method of radiation, the location of adjacent objects, such as buildings, trees, etc., may be determined. The general features of the ground may further be sketched in by eye, and thus, while traversing the ground, a complete and faithful map of the line and all noteworthy adjacent objects may be executed.

**194. By prosection.** The principle depended on in this method for determining the location of points is the intersection of two lines drawn from two points toward a third. Let it be required to make a map of the stations A, B, C, etc., Fig. 190. Measure with great care a base-line MN, so situated that from its two extremities all the stations to be located can be seen. Set up the plane table at one of these stations, as M, and direct the alidade toward N, and draw an indefinite line. On this, set off to some convenient scale *mn*, representing MN.

With the table in the same position, direct the alidade toward each of the stations successively, and draw the indefinite lines *m*A, *m*B, etc. Remove the table to N, place the alidade so as to coincide with *mn*, and then turn the table until the alidade points back toward M. It is then situated in the field as at M. Through *n* draw lines with the alidade

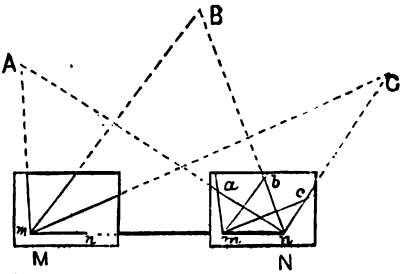



FIG. 100.

toward each station, *n*A, *n*B, etc. The points *a*, *b*, *c*, etc., where lines drawn toward corresponding stations from *m* and *n* intersect each other, will be the true location of the points A, B, C, etc., on the map; and their distances from each other, and from *m* and *n*, will be represented on the same scale as was used in constructing the base-line *mn*.

If we are surveying a definite tract of ground, as a field, one of the sides of the field might be occupied as a base-line when convenient. Or the base-line might be taken entirely outside of the space to be surveyed. The shores of a lake or harbor, or the features of some inaccessible island, may in this way be mapped without occupying any part of it.

**195. By resection.** In this method of using the plane table, one line of the field must be measured, as, for example, AB in Fig. 101. Lay off on the plane-table sheet a line *ab*, representing AB, to a suitable scale. Place the plane table at B, and with the alidade on the line *ab* direct the sights toward A. The line *ab* will then be parallel to AB. With the alidade directed toward C draw the indefinite line *b*C. Remove the table to C, and with the alidade on *b*C point back toward B. Turn the alidade so that, touching the point *a*, it will point toward A. It will intersect the line *b*C in some point *c*, which will be the true location of the point C. Through C draw a line toward D; then remove the table to D, and proceed as at *c*.

While the leading points of the map are thus determined, the location of any other points on either side of the line may be determined by radi-

ation or by prosection. The minute details of the topography may also be sketched in by eye as the survey proceeds.

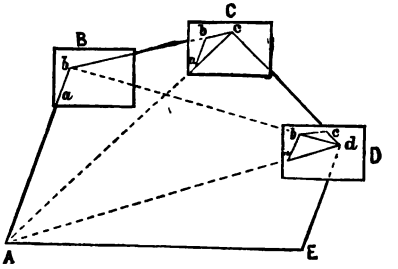



FIG. 101.

**196. To orient the table.** To place the table in such a position that the lines of the plot shall be parallel to the lines of the field, is called **orienting** the table. It signifies the adjustment of the table to the points of the compass, one of which is the orient or east.

In the preceding explanations we have shown how this could be done when the table is located at some point of a line on the ground, which has been drawn upon the table. We need only to lay the alidade on this line, and then turn the table until the telescope points at some other point in the same line.

But when the table is to be removed to some new point P, which is not connected with any other point in the field by a line already constructed, the method there used will not apply. It can always be done approximately by using the compass-box which accompanies the plane table. At any preceding station where the table had been in position, lay the compass-box so that its straight edge shall coincide with any line on the table, and read the bearing of the needle. When the table has been removed to the new point P, lay the compass-box upon the same line and turn the table until the needle indicates the same bearing. The table must approximately be then in the same position as at the preceding station.

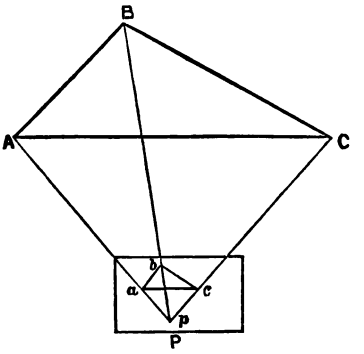



FIG. 102.

**197. Three-point problem.** Whenever we have three stations of the field already located on the plane-table sheet, we can always determine the location of any other point of the field from which these three points can be seen. This is called the three-point problem, and is of the most constant use in operations with the plane table. It includes, of course, the **orientation** of the table at the new station.

Let A, B, C, Fig. 103, be three stations whose positions on the sheet have already been settled at *a*, *b*, and *c*; and let it be required to fix on the sheet the location of the station P, now occupied by the plane table. It is evident if the plane table could be **oriented**, the point would be determined by **resecting** from A through *a*, and from B through *b*, and from C through *c*. These lines ought all to intersect at one point, which would be *p*, the location P.

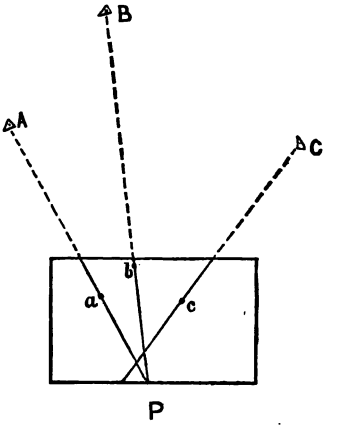


FIG. 103.

Having set the table over the station P, orient it approximately by the compass-box. Then with the alidade draw lines through *a* toward A, through *b* toward B, and through *c* toward C. If the orientation is not perfect, these lines will, by their intersections, form a small triangle, as shown in the figure, called the **triangle of error.**

**198.** From this triangle of error and the three points *a*, *b*, and *c*, the true point can always be obtained by geometrical construction. Thus, let *a*, *b*, *c*, Fig. 104, be the locations of three points A, B, C. Describe a circle through *a*, *b*, and through the intersection of the resection lines drawn through these points. Describe another through *a*, *c*, and through the intersection of their resection lines, and a third through *b*, *c*, and the point *bc*. These circles will intersect each other at some point, which will be the location required.

This construction applies equally to the case where the station P lies within or without the triangle ABC. When the station is within the triangle, the point will be within the triangle of error, and when P is without ABC, will be found without the triangle of error.

The construction of the point, as above described, is attended with so many inconveniences in the field that it is rarely resorted to. The prac-

tised surveyor is able by trial to make the adjustment of the table with great rapidity, and with the additional convenience of avoiding the multiplication of lines upon the sheet.

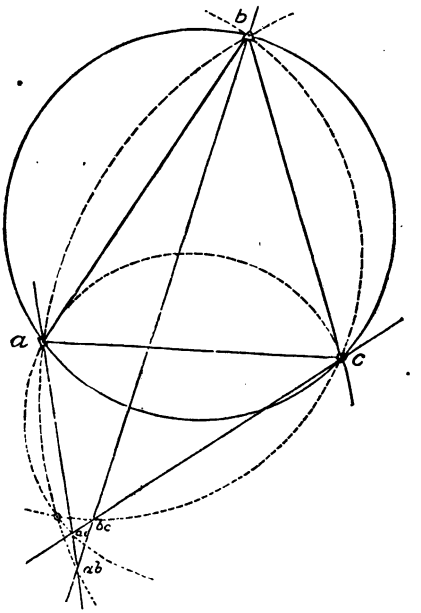



FIG. 104.

The method of determining the position of a point with reference to three points already located, is explained in Problem V., Chapter IV. When the angles from the required point to the known points have been measured, the location of the point may be obtained by the construction there illustrated. The usual plane-table method differs from that in not requiring the actual measurement of the angles.

# CHAPTER XII.

## LEVELLING.

**199.** THE process of **levelling** consists in finding the difference of level between two points, or in finding the heights above a fixed horizontal line of the successive points of a line on the surface of the earth. Two points are said to be in the same level when they are at the same distance from the centre of the earth. A level line or a level surface is one in which all points are equally distant from the centre of the earth. The surface of quiet water is a level surface. Any line or surface parallel to the surface of quiet water would be level.

The subject of levelling belongs to land surveying so far as it serves to determine the variations in the surface of the ground, and the consequent location of roads, drains, watercourses, channels for irrigation, etc. We propose, therefore, to discuss the subject only so far as it is connected with the surveying of lands, and not in reference to general engineering work.

**200.** According to our definition, a level line is a curved line having the centre of the earth for its centre. If a telescope be made level at the point A, Fig. 105, on the surface of the earth, its line of sight would be AT, which is a tangent line to the true level line at that point. The

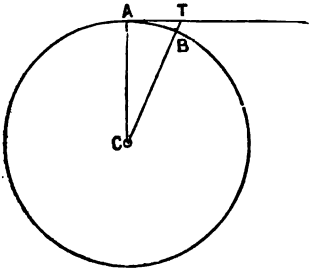



FIG. 105.

line AT is called the **apparent level** line, and AB the **true level**. At the distance AB they differ from each other by the distance BT.

From geometry we know

$$BT\ (2BC + BT) = AT^2.$$

Neglecting BT in comparison with 2BC, and representing the radius of the earth by R, the difference between true and apparent level BT by $h$, and the distance AB, nearly equal to AT, by $d$, we have

$$2Rh = d^2$$

$$h = \frac{d^2}{2R}$$

For 1 mile, $h =$ 8 inches, nearly.
For 2 miles, $h =$ 32 inches, nearly.
For $\frac{1}{2}$ mile, $h =$ 2 inches, nearly.
For $\frac{1}{4}$ mile, $h =$ $\frac{1}{2}$ an inch, nearly.

In general, the value of $h$ varies as the square of the distance. Hence, to find the value of $h$, multiply its value for one mile by the square of the number of miles.

**201.** The effect of the refraction produced on rays of light by the atmosphere is to decrease this difference between true and apparent level by a small amount. The annexed table gives the combined effect of the two corrections, at different distances.

CORRECTIONS OF APPARENT LEVEL, FOR THE EARTH'S CURVATURE AND FOR REFRACTION.

D = distance in feet; $h$ = correction in feet.

| D. | $h$. | D. | $h$. | D. | $h$. | D. | $h$. |
|---|---|---|---|---|---|---|---|
| 300 | .002 | 1800 | .066 | 3300 | .223 | 4800 | .472 |
| 400 | .003 | 1900 | .074 | 3400 | .237 | 4900 | .492 |
| 500 | .005 | 2000 | .082 | 3500 | .251 | 5000 | .512 |
| 600 | .007 | 2100 | .090 | 3600 | .266 | 5100 | .533 |
| 700 | .010 | 2200 | .099 | 3700 | .281 | 5200 | .554 |
| 800 | .013 | 2300 | .108 | 3800 | .296 | 1m. | .571 |
| 900 | .017 | 2400 | .118 | 3900 | .312 | 2m. | 2.285 |
| 1000 | .020 | 2500 | .128 | 4000 | .328 | 3m. | 5.142 |
| 1100 | .025 | 2600 | .139 | 4100 | .345 | 4m. | 9.142 |
| 1200 | .030 | 2700 | .149 | 4200 | .362 | 5m. | 14.284 |
| 1300 | .035 | 2800 | .161 | 4300 | .379 | 6m. | 20.568 |
| 1400 | .040 | 2900 | .172 | 4400 | .397 | 7m. | 27.996 |
| 1500 | .046 | 3000 | .184 | 4500 | .415 | 8m. | 36.566 |
| 1600 | .052 | 3100 | .197 | 4600 | .434 | 9m. | 46.279 |
| 1700 | .059 | 3200 | .210 | 4700 | .453 | 10m. | 57.135 |

**202. Plumb-line level.** The direction of a plumb-line is vertical, and therefore at right angles to a level line. If, therefore, an instrument, having two arms AB and CD at right angles to each other, be so placed that the arm CD is vertical, the other arm AB will be horizontal. By suspending a plumb-line at C, we can determine when CD is vertical. Such an instrument might be employed for finding a level line.

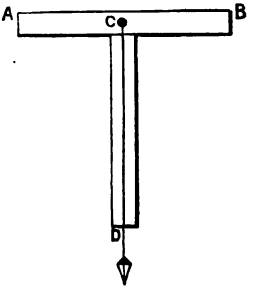



FIG. 106.

**203. Water level.** A tube bent upward at its two ends, and filled with a colored fluid, furnishes a simple expedient for obtaining level lines. The vertical parts of the tube must be of glass; the horizontal part may be of tin or lead, into which the glass ends may be cemented. The glass ends may be corked while the instrument is carried.

When the instrument is set up, and the ends uncorked, the fluid will at

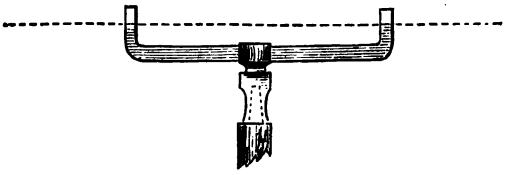


FIG. 107.

once come to the same level in the two ends. By sighting over the surfaces of the liquid in the two ends, a level line will be obtained.

**204. Spirit level.** A ground-glass tube slightly but uniformly bent, is filled with spirits, only leaving a small bubble of air, which will always occupy the highest point of the tube. This bent glass tube is then set in

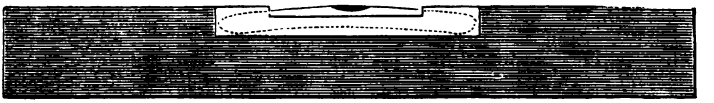


FIG. 108.

a straight brass tube, cut away so as to show the convex side. This may be set in a block of wood having parallel sides, as in the mason's level, or

it may be attached to the horizontal plate of a compass or transit. Its use in this latter case has already been explained, in the chapter treating of angular instruments.

### THE Y-LEVEL.

**205.** The instrument chiefly employed in surveying for determining the differences of level between points, is called **the Y-level.** It is shown in the accompanying plate. It consists of a telescope, somewhat longer than that used in the transit, mounted on two brass supports, from their shape called wyes (Y). The cross-bar to which the wyes are attached is at right angles to the axis or spindle on which it is turned in a horizontal plane. Directly beneath the telescope, and attached parallel to it, is the spirit level, by means of which the line of collimation of the telescope may be rendered horizontal. There is a scale placed on the brass tube of the spirit level, so marked as to show the position of the bubble.

The telescope is provided with a diaphragm at its focus, consisting of a horizontal and vertical thread. The instrument is supported on a tripod and tripod-head, and is levelled, clamped, and moved in the same way as the transit.

**206.** The adjustments of the level are three in number: first, to adjust the line of collimation; second, to render the spirit level parallel to the telescope; and, third, to render the axis perpendicular to the telescope and level.

**To adjust the line of collimation.** Set the tripod firmly, and loosen the collars holding the telescope in the wyes, so that it may be revolved freely. Bring the intersection of the threads upon some small, well-defined object. Then turn the telescope over in the wyes without disturbing the supports. If, on being revolved, the horizontal thread falls above or below the mark, the cross-threads are out of position in that direction. By the small screws provided for that purpose, bring the thread half-way back to the mark; and then, by the levelling-screws, bring it upon the mark. Repeat the same operation until the revolution of the telescope shows no disturbance of the pointing. The same process must be used to adjust the vertical thread.

**207. To adjust the spirit level.** The axis of the spirit level must be parallel to the line of collimation, so that it may serve as an indication of the telescope being level. Open the clips or collars holding the telescope. Bring the telescope over one pair of levelling-screws, and by means of them bring the bubble to the middle. Lift the telescope from the wyes, and replace it in a reversed position. If the level tube is paral-

lel to the telescope, the bubble will remain in the middle. If one end is nearer to the telescope than the other, the bubble will run to that end. Lower that end of the level until the bubble returns half-way back to the middle; then, with the levelling-screws, bring the bubble to the middle. Repeat the operation until the reversal of the telescope in the wyes does not disturb the bubble.

The level tube may sometimes be out of adjustment by not being in the same vertical plane with the telescope, that is, the level may stand awry below the telescope. Roll the telescope a little in the wyes, so that the bubble tube is brought to one side of the cross-bar. If the bubble remains in the centre, the tube is not awry; if the bubble runs to one end, that end projects too far, and must be brought back by the screws provided for the purpose.

**208. To adjust the axis.** The spindle of the instrument must be at right angles to the line of collimation of the telescope, so that when the telescope is levelled, and made to revolve on the spindle, it may describe a horizontal plane surface. The previous adjustments having been effected, bring the telescope directly over one pair of levelling-screws, and bring the bubble to the middle. Unclamp the axis and turn the telescope into a reverse position over the same pair of levelling-screws. If the bubble remains in the middle, the spindle is perpendicular. If it runs to one end, the wye supporting the telescope at that end is too high. By the nuts on the wyes, bring the bubble half-way back, and then, by the levelling-screws, bring it entirely to the middle. Repeat the operation until the reversal of the telescope on its spindle does not disturb the bubble. The adjustment is then complete.

**209. Levelling-rod.** In connection with the levelling instrument above described, a levelling-rod is required. It consists of a long rod of wood, Fig. 109, divided into feet, tenths, and hundredths. It is generally made in two parts, one of which slides down upon the other; when drawn to its full length it is about 12 feet long. A target, or vane, is attached

FIG. 109.

to the rod, and slides up and down upon it. This target carries a small vernier by which the heights are read to thousandths of a foot.

The rod is to be held vertically by an assistant, over any station whose level is to be taken.

**210. To find the difference of level between two stations.** Let it be required to find the difference of level between two stations A and B, Fig. 110. Set up the levelling instrument at some point between the two

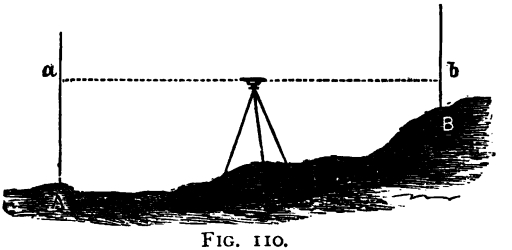



FIG. 110.

stations, and as nearly equally distant as can be estimated, and make it accurately level. Let an assistant hold a levelling-rod at A, and at a signal from his chief move the target up or down until the horizontal thread of the telescope exactly cuts it. The reading of the target will give the distance A*a*, the distance of the line of sight of the telescope above A. The assistant now moves the rod to B, and the distance B*b* is read. It is plain that

The difference of level between A and B = A*a* − B*b*.

It is not necessary in this operation that the level should be placed in a line between A and B. The plane of the instrument is the standard to which the height of both points is referred, and this may be placed anywhere within sight.

If, as was directed, the level is placed equally distant from the stations, the errors arising from the difference between true and apparent level exactly balance each other. For short distances the error may be disregarded. When long sights are used, the observations upon each station must be corrected by the table given in article 201.

**211.** When no station can be found for the level from which the two points can be seen, it is necessary to make use of intermediate stations. Thus, let it be required to find the difference of level between two distant points A and D, Fig. 111. Select some station from which A and also some intermediate station B, in the direction of D may be seen. The readings on A and B will give the difference of level between these two points. Move

the instrument to a new station from which B, and a new point C, further on, may be seen; the observations on these will give the difference be-

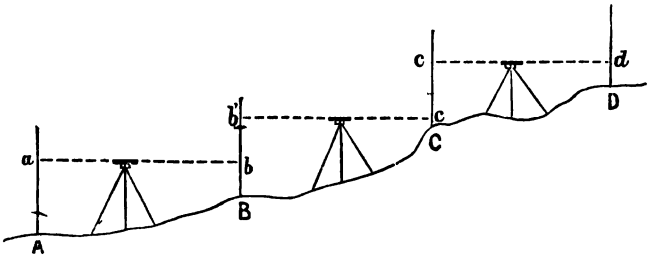



FIG. 111.

tween B and C, which being added to or subtracted from the difference between A and B, will give the difference between A and C. Proceeding thus, we finally obtain the difference between A and D.

**212.** The readings on stations looking backward toward the starting-point A, are called **back-sights.** Those taken on stations looking forward toward D, are called **fore-sights.** From an examination of the figure it will be plain that the difference of level between A and D will be found by taking the difference between the sum of the back-sights and the sum of the fore-sights. If the sum of the back-sights exceeds the sum of the fore-sights, the last point is higher than the first, and *vice versa.*

**213. To level for a section or profile of land.** When the relative elevations of a succession of points A, B, C, Fig. 112, etc., are required, it

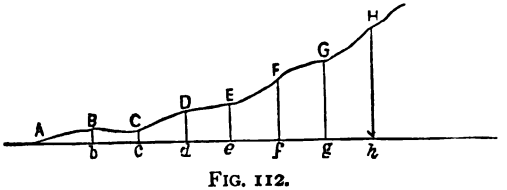



FIG. 112.

is customary to refer all the points to an imaginary horizontal line, which may be assumed to pass through the initial point, or, if more convenient, at any distance below it. This line is called the datum level.

When the surveyor is required to determine the rise and fall of a line running over the surface of the ground, such as a line of road or railroad,

he finds the height of a succession of points, generally at equal distances apart, above a horizontal line AX. Then, having drawn upon paper a horizontal line to represent AX, he lays off upon it the horizontal distances between the points to any suitable scale, and at these points erects perpendiculars representing the heights of the several points. A line joining the summits of these perpendiculars will show the changes in elevation of the ground along this line. Such a representation is called a **profile** or **section.**

Since the changes of elevation are usually much more minute than the horizontal distances, it is customary to use a more exaggerated scale for setting off the perpendicular heights than the horizontal distances.

**214.** In levelling over a line it is not necessary to change the position of the instrument for each new station. The same back-sight will serve to determine any number of stations on which fore-sights may be taken. The instrument should be changed when we are no longer able to see the rods on the forward stations, or when the error from the difference of true and apparent level becomes appreciable. Thus, in the figure, a back-sight

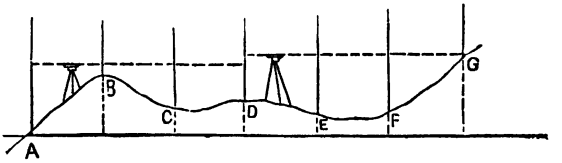



FIG. 113.

on A will determine the relative heights of B, C, and D, on which fore-sights can be taken from the same station. The instrument being moved, a back-sight must be taken on any station already determined, and then fore-sights on any number of succeeding stations.

**215. Field-notes.** The field-notes in levelling consist in a record of the back-sights and fore-sights, with such remarks as are necessary to explain them. When the difference between the first and last station alone is required, the difference between the footings of the back-sights and the fore-sights is all that is required. In levelling for section, the field-notes may be kept in the following form:

| STA. | DIS. | B. S. | F. S. | CHANGE. | HEIGHT ABOVE DATUM. | REMARKS. |
|---|---|---|---|---|---|---|
| A | 100 | 9.34 | | | 0.00 | Datum level through A. |
| B | 100 | | 4.20 | + 5.14 | 5.14 | |
| C | 100 | | 7.83 | + 1.51 | 1.51 | |
| D | 100 | 5.48 | 6.75 | + 2.59 | 2.59 | |
| E | 100 | | 6.60 | — 1.12 | 1.48 | |
| F | 100 | | 6.35 | — 0.87 | 1.72 | |
| G | 100 | | 1.83 | + 3.65 | 6.24 | |

Column I. gives the stations occupied by the levelling-rod.

Column II. gives the distance from each station to the next.

Column III. gives the back-sights.

Column IV. gives the fore-sights.

Column V. gives the change of level between any station, and that on which the preceding back-sight was taken; + signifies a rise, — a fall.

Column VI. gives the heights of the several points above the datum level. In this example, the datum level was assumed to pass through the first station A. Hence, its height is zero. The height of any station is got by adding with its proper sign the change of level to the height of that station on which the last back-sight was taken.

Column VII. contains any remarks or explanations.

**216.** In executing a series of levels, either for determining the difference in level between two points, or for delineating a section, the surveyor ought to make at various points permanent marks, called **bench-marks**, to which he can recur, when occasion requires. The starting-point, or some place near the starting-point, should be thus marked. At all points where, it may be anticipated, branch levels may diverge from, such marks should be left. They consist of some permanent object, such as a point of rock, a stone monument, a stone door-sill, a root of a tree, or other easily recognizable object. They must be marked so that they can easily and unmistakably be found, and described fully in the notes.

These bench-marks will serve, in case by any accident the points occupied in levelling have been lost, to recommence the line of levels. When the work has been left unfinished, a bench-mark will give a point from which to resume.

**217.** The occasions for determining the difference of level between two points occur frequently in the experience of a surveyor. To determine whether a spring of water will flow in a pipe from its source to any

given point, the surveyor must obtain by levelling the difference in height between the two points. To determine the head of water which can be got in any given case, requires the difference of level between two points. In draining a farm, the amount of descent from the ground to be drained to the proposed place of outflow must be ascertained. In the location of roads and railroads, in the improvement of watercourses, in the grading and sewering of the streets of a city, this problem in levelling is of constant use.

Levelling for section is applicable in all branches of engineering work. The first step in preparing to build a road or railroad is to take a system of levels which will enable the surveyor to construct a section of the ground over which it is proposed to be run. For this purpose, he obtains the elevations of a series of points in this line above some assumed fixed level line. These, when plotted on paper, will show to the eye the changes of elevation along the line, and will show where in the construction the surface will require excavation, and where filling.

**218. Topographical levelling.** In order to ascertain and delineate the changes of level, and the comparative declivity of different parts of a piece of ground, we conceive the surface intersected by a series of horizontal planes, beginning with one passing through the lowest point, and each succeeding one being placed at a certain uniform distance above the preceding. The intersections of these planes with the ground-surface will give a series of irregular curve-lines, all the points in any one of which would be in the same level. These lines are termed **contour lines**, and when plotted on a horizontal plan of the ground, serve to show its topographical features. When the contour lines in such a plan approach near together, it shows the ground to be steeper than when they are more distant. The location of valleys, ridges, declivities, and plains is easily recognized from the distribution of the contour lines.

**219.** The chief object of topographical levelling is to locate these contour lines. When the ground is small in extent and easily seen from a small number of stations, the surveyor can proceed as follows:

Set up the level at some point commanding a view of as much space as possible, including the lowest point of the ground. Take a back-sight upon the lowest point. Then lower the target by whatever interval is to be left between the horizontal planes; for example, one foot. Let the rod be moved to higher ground until the target is again brought to the level of the telescope; this is one point in the one-foot contour line. With the target at the same point, move the rod until another point is found. Mark the points thus found; they will constitute the one-foot contour line. The target may now be lowered another equal interval, and the points of the second contour line be located.

When the surveyor can no longer follow the rod from his first position, he moves to a new position from which he can see the rod on some point already occupied, and as much additional space as possible. Placing the rod on the known point, the target is adjusted to the new position of the level, and then the work proceeds as before.

The location of these lines on a map may be effected by running them with a compass and chain.

**220.** The method employed when the ground is of considerable extent will be seen from the following example:

Let it be required to locate the contour lines on a plot of ground

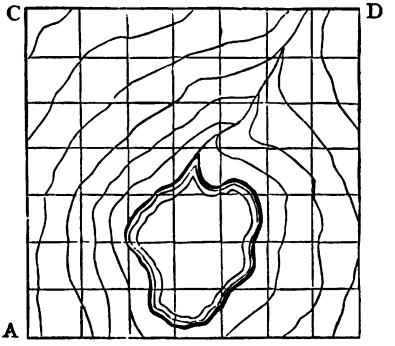



FIG. 114.

ABCD. With the transit or otherwise run two sets of parallel lines dividing the field into equal squares. At the intersections set pegs and number them. Then with the level determine the height of each peg above some standard; for example, the surface of the pond.

Having drawn a plot of the ground, lay down upon it in light pencil-lines the squares as run in the field. From the field-notes we know the height of each point, and therefore we know how much the ground rises along each line from peg to peg. From this we can estimate where each of the contour lines cuts the parallel lines. Having thus found where the one-foot contour line cuts each of the lines in the field, draw an irregular curve-line through these points, and it will be the contour line required. In the same way find the points and draw each contour line. In general the estimate can be made with sufficient accuracy by eye.

**221.** Numerous applications of the principle of topographical levelling will be met with by the surveyor. In surveying a city for the purpose of laying down water-pipes, or for devising a system of sewerage,

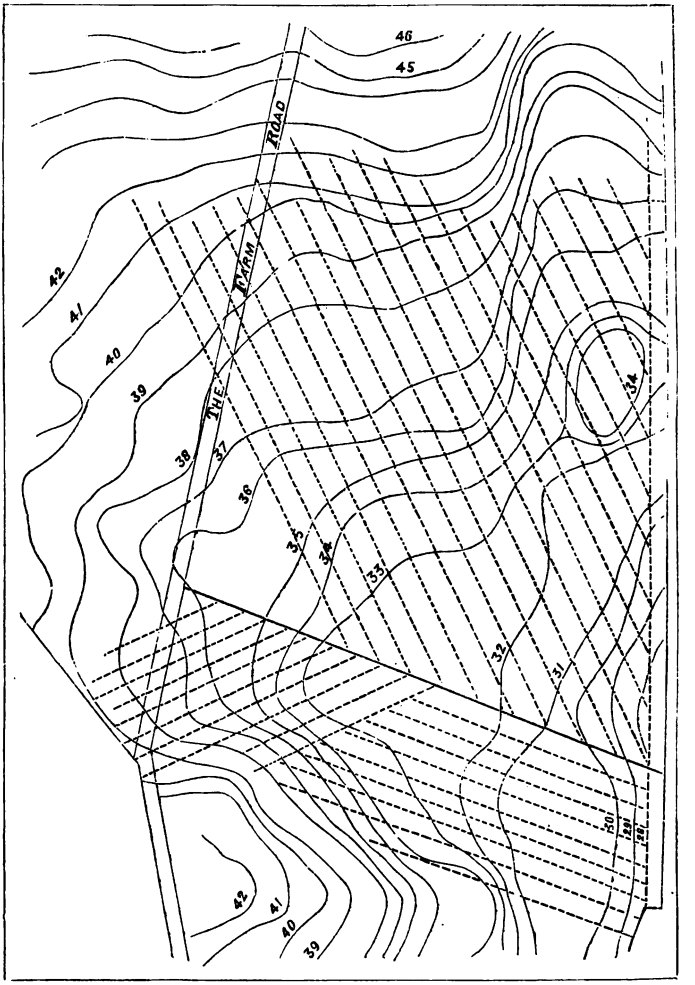



FIG. 115.—MAP OF NEW JERSEY AGRICULTURAL COLLEGE FARM, SHOWING THE CONTOUR LINES.

the heights of all the street intersections above the lowest point, or above tidewater, are to be determined by the level. With these a system of contour lines, rising one above another at uniform intervals, can be laid down upon a city-map. Such a map will show at a glance the fall along any street, the proper outlet for the sewerage of any district, and the proper streets to be connected together in one district.

The same method, if applied to a farm, would show the relative heights of all parts, and the proper location and arrangement of a system of drains. To illustrate the use of such a survey we insert a map of a portion sf the New Jersey Agricultural College Farm, at New Brunswick, Fig. 115. The contour lines are drawn at intervals of one foot. The heavy line shows an open ditch for receiving the drainage, and the broken lines the underdrains so far as executed. In laying down a system of drains it is necessary to make the lines of drainage cut the contour lines as nearly at right angles as possible, because this, being the line of quickest descent, will secure a most rapid flow of the water.

# CHAPTER XIII.

## UNDERGROUND SURVEYING.

**222.** For the purpose of delineating the excavations of mines, tunnels, etc., the operations of surveying must frequently be conducted underground. To meet the exigencies of these cases some modifications in the instruments and methods employed in surface surveying are rendered necessary. Ordinary flags or other signals cannot be seen ; hence lanterns with various colored lights are substituted. The compasses, theodolites, and transits used are arranged, graduated, and mounted in a manner suited to the changed circumstances.

**223.** To measure the **lines** of an underground survey, a Gunter's chain, or the 100-feet engineer's chain, is used. The chain is not held horizontal, but the measurement is made along the slope of the gallery. At the same time the angle of inclination of each slope is measured by means of a semicircle, and recorded opposite to the measured distance. The horizontal distances may be deduced by multiplying the length of each line by the cosine of the inclination, and the rise or fall for each slope may be deduced by multiplying the length by the sine of the inclination. The following table shows how such distances and their reductions may be recorded. The positive sign signifies a rise, and the negative a fall.

| COURSES. | DISTANCES. | INCLINATIONS. | HOR. DIS. | RISE OR FALL. |
|---|---|---|---|---|
| AB | 56.4 | — 16° 30′ | 54.1 | — 18.2 |
| BC | 86.0 | + 20 15 | 80.7 | + 29.8 |
| CD | 21.8 | 0 | 21.8 | 0 |
| CE | 40.8 | — 18 45 | 38.6 | — 13.1 |

**224.** The **terminations** of the courses may be marked by iron pins driven into holes drilled for the purpose ; or when these points are only temporary and are not required for future reference, they may be marked with chalk. The chainmen may also mark the ends of the successive chain-lengths with chalk. Lamps are employed as signals at the successive stations to guide the chainmen in running the lines, and also for signals in measuring the angles.

**225.** When the dimensions of the cross-section of the gallery are required, they are measured at right angles to the traverse line. A hand-

diagram of the cross-section is made in the note-book, and on it are written the measurements necessary to determine its area. The distance of each cross-section from the last preceding station is recorded in the notes and noted on the sketch.

Fig. 116 shows the sketch of a cross-section. The dimensions marked upon the diagram are sufficient to determine the area. It must also be marked in such a way as to indicate at what point of the traverse it was taken.

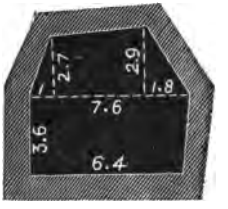



FIG. 116.

**226.** The instrument used for **measuring angles** in subterranean surveying is usually either the magnetic compass or the transit. When ferruginous substances are present the compass cannot be conveniently employed, on account of the deflection of the needle. Whenever it is employed, care must be used by taking back-sights as well as fore-sights, to detect the presence of local attraction, and to eliminate the error. The angular instrument is mounted on a low tripod or on a box; or by some surveyors is suspended by a hook from a wire running through the gallery, and fastened from station to station of the traverse. In the latter case the instrument must be mounted so as to hang horizontal, somewhat after the manner of a ship-compass.

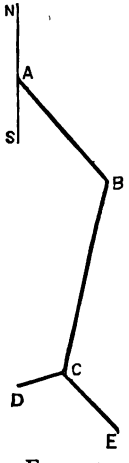



FIG. 117.

When the transit or a compass provided with a telescope is used, some method of **illuminating the cross-wires** is required. Instrument-makers furnish for this purpose a small reflector and lamp, to be suspended so as to throw a faint light through the object-glass upon the cross-wires.

**227. To run the traverse with the compass.** Place the compass at the station where the survey is to be begun, for example, in Fig. 117, at A, the centre of the shaft running up to the surface. Point the compass toward a signal-lamp at B, held at the same height as the compass. Read the bearing of the line AB from the magnetic meridian. Measure also the distance AB, and its angle of inclination. When required, measure also the cross-section at suitable intervals.

Remove the compass to B, and measure the reverse bearing of BA. The agreement of this with the direct bearing will test the local attraction. Measure also the direct bearing of BC, and so proceed till all the

lines and bearings are measured. A record like the following may be made of the work:

| LIN. | DIS. | INCL. | DIRECT BEARING. | REVERSE BEARING. | REDUCED BEARING. | REMARKS. |
|---|---|---|---|---|---|---|
| AB | 56.4 | — 16° 30′ | S. 48° 30′ E. | 48° 38′ | S. 48° 34′ E. | |
| BC | 86.0 | + 20 15 | S. 10 48 W. | 10 40 | S. 10 44 W. | 68 section. |
| CD | 21.8 | 0 | S. 80 18 W. | 80 24 | S. 80 21 W. | 5 section. |
| CE | 40.8 | — 18 45 | S. 42 11 E. | 42 15 | S. 42 13 E. | |

**228.** To discover at which station local attraction disturbs the magnetic needle, the surveyor sets up the compass at some intermediate station, and points it along the same line. If it agrees in reading with that at either end, the reading at that end may be regarded as free from disturbance, and may be used to correct the other. Thus, suppose in the preceding example it is found that the reverse bearing at station B, instead of exactly agreeing or nearly agreeing with the direct, is 49° 45′. The difference, 1° 15′, is too large to be treated as an error of measurement, and must be regarded as the amount by which the north end of the needle is attracted to the east. Hence, when the compass is pointed along BC, the reading will be affected 1° 15′ by this divergence of the needle. Since the south end of the needle points too far to the west, the reading of BC will be S. 9° 33′ W., too small by 1° 15′, and the true reading will be obtained by adding the correction.

The following rule will show how to apply this correction to the next bearing:

When the reverse bearing exceeds the direct, **subtract** the difference from the next direct bearing, if both the courses have both the letters alike, or both different; or **add** the difference when one set of letters are alike, but the other different.

When the direct bearing exceeds the reverse, **add** the difference to the next direct bearing, when both the courses have both the letters alike, or both different; or, **subtract** the difference when one set of letters are alike, but the other different.

**229.** By measuring the internal angles instead of the bearings of the courses, the magnetic compass may be used for running the traverse of an underground survey, even when the local attraction prevents our obtaining from it the true bearings of the courses. Set up the compass at the second station B, in the preceding example. The included angle ABC, measured with the compass, will be precisely the same, whether the needle is disturbed by local attraction or not. Thus:

The bearing of BA, N. 48° 30′ W.
The bearing of BC, S. 10° 48′ W

By Art. 53, angle ABC = 180° − (48° 30′ + 10° 48′) = 120° 42′.

The disturbed bearing of BA, N. 49° 45′ W.

The disturbed bearing of BC, S. 9° 33′ W.

By Art. 53, the angle ABC = 180° − (49° 45′ + 9° 33′) = 120° 42′.

In the same way the compass may be set up at each of the intermediate stations, and the angles between the courses determined, the result in each case being independent of any local attraction.

The bearings of the courses, in this case, with the meridian, will not be known. If, however, the true bearing of any one of the courses could be determined by connecting with known lines on the surface, the bearings of the remainder can be deduced from the known angles which they make with each other.

**230. To run the traverse with the transit.** Place the transit over the second station, as B, Fig. 117. Place signal-lamps at the preceding and succeeding stations, A and C, taking care to locate them at the same height above the ground as the telescope of the transit. Measure the horizontal angle ABC, and also, by means of the vertical circle of the transit, read the slope of the lines. Remove the transit to the next station C, and measure the horizontal and slope angles in the same way.

A convenient arrangement is for the surveyor to be provided with three tripods of equal height. They are so constructed that when the transit is taken off, a lantern may be put on which will stand at the same height as the telescope of the transit. The three tripods are set up at three continuous stations. On the middle one the transit is set, and lanterns on the others. When the angles at this station are measured, the tripod from the first station is carried forward to an advance station, the lantern from the third is placed on the second, and the transit is placed on the third tripod.

The transit used in subterranean surveying is commonly graduated from 0° to 360° in the direction of the numbering on a watch-face.

**231.** The field-notes of the survey may be kept in the same way as described for transit surveying in Art. 148. Or they may be kept in a tabular form, as follows:

| STA. | DIS. | SLOPE. | HOR. DIS. | RISE. FALL. | B. S. | F. S. | INT. ANG. |
|---|---|---|---|---|---|---|---|
| A | | | | | | | |
| B | 208 | + 3° 45′ | 207.5 | + 13.6 | 278° 30′ | 160° 0′ | 241° 30′ |
| C | 168 | − 2 30 | 167.8 | − 7.3 | 25 38 | 136 52 | 111 14 |
| D | 300 | − 2 50 | 299.6 | − 14.8 | 348 36 | 249 40 | 261 4 |
| E | 316 | 0 | 316.0 | 0 | 323 51 | 106 7 | 142 16 |
| F | 114 | + 4° 15 | 113.7 | + 8.4 | | | |

**Column I.** contains the stations in their order of succession. In this example we have supposed the galleries to succeed each other. But often galleries branch off from the same station in different directions. The notes must indicate this.

**Column II.** contains the distances measured along the slopes of the galleries. They are placed so as to show the distance of the station opposite to which they stand from the preceding.

**Column III.** contains the angles by which the lines from the preceding station slope to the station named opposite. The positive sign indicates a rise, the negative a fall.

**Column IV.** contains the horizontal distances obtained by multiplying the distances in Column II. by the cosine of the slope.

**Column V.** contains the rise or fall of each station from the preceding, obtained by multiplying the distances in Column II. by the sine of the slope.

**Columns VI. and VII.** give the readings of the transit when pointed respectively upon the preceding and succeeding stations. They are set opposite to the station at which the angles were measured.

**Column VIII.** is obtained by subtracting the back-sights in Column VI. from the fore-sights in Column VII. Whenever, in turning the instrument from the back-sight to the fore-sight, we pass the 360° point, we must add 360 to the reading of the fore-sight before we subtract.

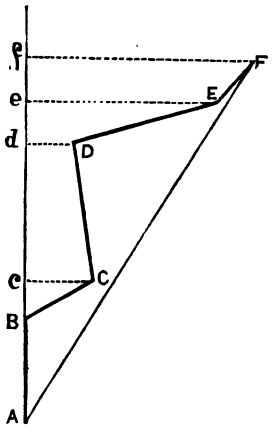



FIG. 118.

When the remainder is less than 180° it shows that the next course turns to the left; when it is greater than 180° it shows that the next course turns to the right.

**232. To reduce the traverse.** Let it be required in the last example to determine the horizontal distance and direction of the last station from the first. Let ABCDEF, Fig. 118, represent a horizontal plot of the preceding example: it is required to find the line AF and the angle BAF. By referring all the courses to the meridian of the first course, it is plain that A*f*, the latitude of the last station, is the sum of all the latitudes of the courses, and that F*f*, the departure of the last course, is equal to the sum of the departures of all the courses. The length and bearing of AF can readily be obtained from the values of A*f* and F*f*.

To obtain these, proceed as in transit surveying. The operation is summed up in the following table:

| STA. | HOR. DIST. | HOR. ANG. | AZIMUTH WITH 1ST COURSE. | BEARINGS. | LATITUDE. N. | LATITUDE. S. | DEPARTURE. E. | DEPARTURE. W. |
|---|---|---|---|---|---|---|---|---|
| A | | | 0 | N. | 0 | | | |
| B | 207.5 | 241° 30′ | 241° 30′ | N. 61° 30′ E. | 207.50 | | | |
| C | 167.8 | 111 14 | 172 44 | N. 7 16 W. | 80.07 | | 147.46 | |
| D | 299.6 | 261 4 | 253 48 | N. 73 48 E. | 297.19 | | | 37.90 |
| E | 316.0 | 142 16 | 216 4 | N. 36 4 E. | 88.16 | | 303.45 | |
| F | 113.7 | | | | 91.91 | | 66.64 | |
| | 1104.6 | | | | 764.83 | 0 | 517.55 | 37.90 |
| | | | | | $Af$ = 764.83 | | $Ff$ = 479.65 | |

The column of azimuths in this table is derived from the column of horizontal angles by the following rule:

Subtract 180° from the horizontal angle which any course makes with the preceding. The remainder may be + or −. Add the result, observing its proper sign, to the azimuth of the preceding course. If the sum is negative, add 360° to it; if positive and greater than 360°, subtract 360°. The result will be the azimuth of the next course.

The bearings are marked from the first course as a meridian, and are obtained in a manner similar to that described in Art. 154.

The solution of the right-angled triangle AF$f$ will give the unknown quantities AF and angle FA$f$.

To find the angle:

$$\tan \mathrm{FA}f = \frac{\mathrm{R} \times \mathrm{F}f}{\mathrm{A}f} = 32^\circ\ 5'\ 35''$$

To find the distance:

$$\mathrm{AF} = \frac{\mathrm{R} \times \mathrm{F}f}{\sin \mathrm{A}} = 1439.55$$

**233. To connect the underground survey with lines on the surface.**

In order to trace on the surface the extent and direction of the underground excavations, and also to ascertain the depth below the surface of any point, the surveyor must connect his traverse underground with lines on the surface. When the compass has been used in the survey, and we have obtained, free from local attraction, the magnetic bearing of the line

running from the bottom of the shaft, the extension of the survey to the surface may be effected thus:

Suspend a plumb-line from the surface down the shaft directly over station A. To keep it steady, it may be made to hang in a bucket of water. By means of this plumb-line, set the compass at the top of the shaft, directly over station A at the bottom. A temporary platform may be built over the shaft. Turn the compass until the bearing of the sights is the same as that of the first course of the underground survey. This line being run out would correspond with and be vertically over the first course. Precautions must be used to prevent the iron implements, etc., about the shaft, disturbing the needle.

When it is not convenient to set the compass directly over the shaft, the location of the first line may be got as follows:

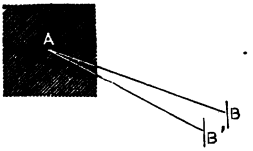


FIG. 119.

Set up the compass at any point B', Fig. 119, approximately in the required direction. Sight back on A, the suspended plumb-line; if the compass is truly in line, its bearing will correspond with the reverse bearing of the first course. By trial, move the compass until the bearing corresponds; it is then in the required line.

Having obtained the direction of the first line on the surface corresponding with the first line underground, the surveyor can repeat on the surface the entire traverse.

**234.** When the transit has been used for making the survey, the connection with the surface may be established by suspending two plumb-lines as shown in Fig. 120. Set up the transit at B, the second station, and point it back at A, the first station. From a rod reaching across the mouth of the shaft, suspend two plumb-lines CE and DF, as far apart as the width of the shaft will allow. Move the rod carrying the plumb-lines until they are both exactly in the line of sight of the telescope. The points CD will then be two points in the required surface-line. It is a serious objection to this method that the plumb-lines can only be placed at a small distance apart, and hence the surface-line cannot be regarded as fixed with great precision.

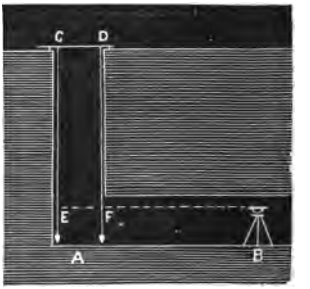


FIG. 120.

**235.** Fig. 121 shows a second method by which a transit may be employed to connect an underground with a surface survey. Set the transit on the edge of the shaft, in such a way as to be able to see diagonally across the shaft in the direction of the gallery. Fix a fine distinct mark at G in this line. Also fix a mark D upon the surface, in the same direction. From a straight-edge placed across the shaft from the instrument in the line CD, suspend a plumb-line EF. The line through the points F and G, in the underground survey, corresponds with CD on the surface. The direction which the line through FG makes with the first line of the survey can easily be determined.

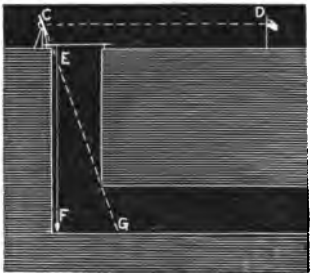



FIG. 121.

The transit may, in this operation, be placed at the bottom of the shaft G instead of the top. A diagonal eye-piece is then required to enable the surveyor to make observations nearly vertical up through the shaft.

**236.** Being able to locate on the surface the first line of the underground traverse, the surveyor can now locate points directly over each of the stations of the underground survey. In this operation it must be remembered that the horizontal distances between the stations are to be used.

Let it be required, in the preceding example, Fig. 118, to locate on the surface the last station F of the survey, and also to determine the depth below the surface. Having measured the horizontal distance of the first course, 207.5 at this point, measure a horizontal angle 241° 30′ from the preceding course, and measure the horizontal distance of the second course. Proceed thus to measure the horizontal angles and the horizontal distances of the traverse. Each of the stations on the surface will be directly over those of the underground survey.

Or, having determined the direction of the first course, and reduced the traverse as in Art. 232, measure the angle BAF 32° 5′ 35″, and also the horizontal distance AF 1439.5 feet. The point thus reached on the surface will be directly over F of the subterranean survey.

**237.** To determine the **depth** of the point F below the surface, find the difference of level between the mouth of the shaft and the point over F. This difference and the known depth of the shaft will give the difference of level between the bottom of the shaft and the required point. Finally, from the rise and fall in the gallery, we know the change of level

from the bottom of the shaft to the underground station, and this, applied to the previous difference, will give the depth required. Thus,

Required depth = depth of shaft + rise of surface (or — fall) — rise of gallery (or + fall).

**238.** The results of the survey may be represented on paper by making a **horizontal plan** of the traverse, and also laying down upon it the width of the gallery as determined by the measurement of the cross-section. This will show the horizontal extent and directions of the underground excavations. A **vertical section** is also constructed, running through the traverse line of the galleries, without taking into account its changes of horizontal direction. The vertical scale may be exaggerated over the horizontal, if that is necessary, to show the vertical changes. This section will show the bottom of the gallery with all changes of level, the height of the gallery, the depth of the shafts, and also the position of the surface directly over the gallery.

# EXPLANATION OF TABLES.

## TABLE I. USEFUL FORMULÆ.

**239.** THIS table gives, in a form convenient for reference, the principal formulæ of trigonometry and mensuration which are required in surveying. In the chapter on Trigonometry will be found the demonstration of those relating to triangles. Those relating to the areas and surfaces and contents of geometrical figures will be found demonstrated in the works on geometry. To these are added a few miscellaneous formulæ of frequent use.

## TABLE II. USEFUL NUMBERS AND THEIR LOGARITHMS.

**240.** Numbers of frequent application are here given, together with their logarithms. They will save the computer some labor, and may be relied on as obtained from the most authentic sources.

## TABLE III. LOGARITHMS OF NUMBERS.

**241.** This table gives the logarithms, carried to six decimal places, of all numbers consisting of four figures or less; and also furnishes the means for finding the logarithms of numbers of five or more figures. The characteristic, that is, the integral part of the logarithm, is not expressed in the table, but may always be found by the following rule:

**The characteristic of the logarithm of a number greater than unity, is one less than the number of integral figures in the given number. Thus the characteristic of the logarithm of 365.25 is 2.**

**The characteristic of the logarithm of a decimal fraction is negative, and is equal to the number of places by which the first significant figure is removed from the place of units. Thus the characteristic of the logarithm of 0.0038 is $\bar{3}$.** To distinguish the negative sign in this case where it only applies to the characteristic, and not to the decimal part of the logarithm, it is placed over the characteristic.

**242. To find the logarithms of numbers consisting of three figures or less.**

Find the number in the first column of the page headed N; then the logarithm will be found opposite, in the second column headed 0. To this must be prefixed the characteristic required by the rule.

Since the decimal part of the logarithm of a number of two figures, for example 36, is the same as that of the same number with a cipher attached, that is 360; when the number consists of less than three figures, we seek in the first column for these figures with a cipher or ciphers attached. Thus, to find the logarithm of 36, we seek opposite 360.

**243. To find the logarithm of a number of four figures.**

Seek the first three figures in the N column, and the fourth at the top of one of the columns. Opposite the three figures, and beneath the fourth, will be found the required logarithm.

**244. To find the logarithm of a number of five or more figures.**

Find the logarithm corresponding to the first four figures, as above. Take the number standing opposite in the difference column, and multiply this by the remaining figures of the number used as a decimal. The product will form a correction to be added to the logarithm of the four figures. Thus, to find the logarithm of 683237:

| | |
|---|---|
| Opposite 3862 we find | .586812 |
| Correction = 112 × .37 | 41 |
| Result with characteristic | 5.586853 |

**245.** When the number is **wholly or partly decimal**, the decimal part of the logarithm is found as if the figures were all integral; and then the proper characteristic is prefixed. Thus, the logarithm of 0.00486 is found opposite 486, and the characteristic $\bar{3}$ is prefixed. The logarithm for 96.83 is found opposite 9683, and the characteristic will be 1.

**246. To find the number corresponding to any logarithm.**

Seek in the table for the logarithm nearest less than the one given, and take out the three figures in the N column and the figure at the top. These are the first four figures of the required number. Subtract the tabular logarithm from the given logarithm, and divide the remainder with ciphers annexed by the number standing opposite in the difference column. The quotient will give figures to be annexed to the four already found. The division may be carried as far as the desired precision requires. The characteristic will indicate where the decimal point must be placed. Thus, let it be required to find the number corresponding to

| | |
|---|---|
| Logarithm ..... | 3.486329 |
| Nearest less logarithm ..... | .486289 |
| Remainder ..... | 40 |
| 40 + 142 ..... | 282 |
| Number corresponding..... | 3064.282 |

TABLE IV. LOGARITHMIC SINES, COSINES, TANGENTS, ETC.

**247.** This table gives the logarithms of the sines, cosines, tangents, and cotangents of all arcs from 0° to 90°, at intervals of one minute. They are computed for a radius of 10 000 000 000, whose logarithm is 10. When this table is used in formulæ involving the radius, the logarithmic radius 10 must be employed. The table is not carried beyond 90°, because the functions for arcs above 90° are the same as those of their supplements. Thus:

$$\begin{aligned} \text{Sin } 100^\circ &= \quad \sin 80^\circ \\ \text{Cos } 100 &= -\cos 80 \\ \text{Tan } 100 &= -\tan 80 \\ \text{Cot } 100 &= -\cot 80 \end{aligned}$$

**248. To find the logarithmic sine or tangent of any arc.**

If the arc is less than 45°, find the number of degrees at the top of the page, and the minutes at the left hand. If the arc is more than 45°, find the degrees at the bottom of the page, and the minutes at the right hand. In the appropriate column opposite the given minutes will be found the required logarithmic sine or cosine.

When the arc contains seconds, take out the difference for 1″ opposite the logarithm for the given degrees and minutes. Multiply this by the given seconds, and the product forms a correction which must be **added** to the logarithm opposite the given degrees and minutes.

The **cosines** and **cotangents** are found from the tables in the same manner, except that the correction obtained for the seconds must be **subtracted.**

To find the sine of 25° 38′ 16″:

| | |
|---|---|
| Sin 28° 38′ ..... | 9.636097 |
| Correction 4.39 × 16 ..... | 70 |
| Sin 28° 38′ 16″ ..... | 9.636167 |

To find the cotangent of 119° 12′ 22″:

| | |
|---|---|
| Cot 119° 12′ 22″ = − cot 60° 47′ 38″ | |
| Cot 60° 47′ ..... | 9.747616 |
| Correction 4.94 × 38 ..... | −188 |
| Cot 60° 47′ 38″ ..... | 9.747428 |

**249.** The **secants** and **cosecants** of arcs are not included in the table. They may be found from equations (2) and (4), Art. 13.

$$\text{Sec } a = \frac{R^2}{\cos a}; \quad \text{cosec } a = \frac{R^2}{\sin a}$$

Hence, $\log \sec a = 2 \log R - \log \cos a$

and $\log \operatorname{cosec} a = 2 \log R - \log \sin a$.

Thus, to obtain the logarithmic secant of 36° 16′:

| | |
|---|---|
| 2 log R | 20.000000 |
| Cos 36° 16′ | 9.906482 |
| Sec 36° 16′ | 10.093518 |

**250. To find the arc corresponding with any logarithmic sine and tangent.**

Find in the proper column the logarithm next less than the one given; take the degrees and minutes corresponding; subtract the tabular logarithm from the one given; divide the remainder by the difference for 1″ standing in the proper difference column; the quotient will be the seconds to be annexed to the degrees and minutes.

The method for finding the arc corresponding to a given cosine or cotangent is similar, except that we find the next greater logarithm instead of the next less.

Thus, to find the arc corresponding to a tangent 10.684639:

| | | |
|---|---|---|
| Given tangent | 10.684639 | |
| Tabular tangent | 10.684477 | arc 78° 19′ |
| Remainder | 162 | |
| Correction, 162 ÷ 10.61 = | 15″ | |
| Whole arc | 78° 19′ 15″ | |

To find the arc corresponding to a cosine 9.964418:

| | | |
|---|---|---|
| Given cosine | 9.964418 | |
| Tabular cosine | 9.964454 | arc 22° 52′ |
| Remainder | 36 | |
| Correction, 36 ÷ .89 | 40″ | |
| Whole arc | 22° 52′ 40″ | |

## TABLE V. NATURAL SINES AND COSINES.

**251.** This table gives the sines and cosines of all arcs from 0° to 90°, at intervals of one minute to five decimal places. The radius for this table being unity, the values of all sines and cosines are less than one.

**To find the sine and cosine for any arc:**

If the arc is less than 45°, seek the degrees at the top, and the minutes at the left hand of the page. If the arc is more than 45°, seek the degrees at the bottom, and the minutes at the right hand of the page. The required sine or cosine corresponding to the given number of degrees

and minutes will be found in the column of the degrees and opposite the minutes.

When the given arc consists of degrees, minutes, and **seconds,** find the sine or cosine corresponding to the degrees and minutes. Subtract this sine or cosine from that belonging to the next greater arc. The difference is the change for 1 minute or 60 seconds. Multiply this difference by the given seconds, and divide by 60. The quotient is the correction which the sine or cosine requires for the additional seconds. In the case of the sine, add the correction ; in the case of the cosine, subtract.

Thus, let it be required to find the sine of 28° 14′ 36″ :

Sine 28° 14′ = .47306 ; diff. = 26

Correction for 36″ $= \frac{26 \times 36}{60} = 16$

Sine 28° 14′ 36″ = .47322

Let it be required to find the cosine of 61° 29′ 25″ :

Cosine of 61° 29′ ..... .47741 ; diff. = 26

Correction for 25″ $= \frac{26 \times 25}{60} = -11$

Cosine 61° 29′ 25″ ..... 47730

**252. To find the arc corresponding to any given natural sine and cosine.**

Find in the table the two consecutive sines or cosines between which the given one falls. The least of these, in the case of the sine, corresponds to the required **degrees** and **minutes** ; in the case of cosines, the greater. Take the difference between the given sine and cosine, and that answering to the degrees and minutes. Take, also, the difference between the two consecutive sines and cosines. Multiply the first difference by 60, and divide the product by the second difference. The result will give the required **seconds.**

Thus, let it be required to find

The arc whose sine is..... .60000
Nearest less tabular sine..... .59995 .. 36° 52′
Difference..... 5
Difference between consec. sines.. 24

Required seconds $= \frac{5 \times 60}{24}$.... 12″

Required arc.....36° 52′ 12″

Again, let it be required to find

| | | |
|---|---|---|
| The arc whose cosine is | .94660 | |
| Nearest greater tabular cosine | .94665 .. | 18° 48′ |
| Difference | 5 | |
| Difference between successive cosines | 9 | |
| Required seconds $= \frac{5 \times 60}{9}$ | 33″ | |
| Required arc | 18° 48′ 33″ | |

TABLE VI. NATURAL TANGENTS AND COTANGENTS.

**253.** This table gives the tangents and cotangents computed for a radius of unity for all arcs from 0° to 90°. The tangents vary between 0 and infinity, and the cotangents between infinity and radius. The variations of the tangents near the end of the quadrant and the cotangents near the beginning of the quadrant are so rapid that the table cannot be relied upon to give them for intermediate seconds when the arc lies within one or two degrees of those points. But angles of that character are very unusual in surveying, and when they are required, resort must be had to tables adapted for this purpose.

**254. To find the tangent or cotangent corresponding to a given arc.**

If the arc is less than 45°, seek the degrees at the top of the page, and the minutes at the left hand. If the arc is more than 45°, seek the degrees at the bottom of the page, and the minutes at the right hand. The required tangent or cotangent corresponding to a given number of degrees and minutes will be found in the column of the degrees and opposite the minutes.

When the given arc consists of degrees, minutes, and **seconds**, find in the table two consecutive tangents and cotangents between which the required one must fall. Take their difference, and multiply it by the given seconds, and divide by 60. The quotient will give a correction for the number opposite the degrees and minutes, to be added in case of the tangent, and subtracted in case of the cotangent.

Thus, let it be required to find the tangent of 48° 44′ 23″:

| | | |
|---|---|---|
| Tangent of 48° 44′ | 1.13961 ; | diff. 67 |
| Correction for 23″ $= \frac{67 \times 23}{60} =$ | 26 | |
| Tangent of 48° 44′ 23″ | 1.13987 | |

Again, let it be required to find the cotangent of 74° 16′ 45″:

| | | |
|---|---|---|
| Cotangent of 74° 16′ | 0.28172 ; | diff. 32 |
| Correction for 45″ $= \frac{32 \times 45}{60} =$ | −24 | |
| Cotangent of 74° 16′ 45″ | 0.28148 | |

**255. To find the arc corresponding to any given tangent or cotangent.**

Find in the table the two consecutive tangents or cotangents between which the given one falls. The less of these in the case of the tangent corresponds to the required degrees and minutes; in the case of the cotangent, the greater. Take the difference between the given tangent or cotangent and that answering to the degrees and minutes. Take also the difference between the two consecutive tangents or cotangents. Multiply the first difference by 60, and divide by the second. The result will give the required **seconds**.

Thus, let it be required to find

| | | |
|---|---|---|
| The arc whose tangent is | 3.48462 | |
| Nearest less tangent | 3.48359 | 73° 59′ |
| Difference | 103 | |
| Difference between consecutive tangents | 382 | |
| Required seconds $\frac{103 \times 60}{382} =$ | 16″ | |
| Required arc | | 73° 59′ 16″ |

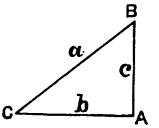
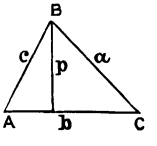
Again, let it be required to find

| | | |
|---|---|---|
| The arc whose cotangent is | 2.50000 | |
| Nearest greater cotangent | 2.50018 | 21° 18′ |
| Difference | 18 | |
| Difference between consecutive cotangents | 211 | |
| Required seconds $\frac{18 \times 60}{211} =$ | 5″ | |
| Required arc | | 21° 18′ 5″ |

# TABLE I.

## USEFUL FORMULÆ.

### LINES AND ANGLES.

| FIGURE. | GIVEN. | REQUIRED. | FORMULÆ. |
|---|---|---|---|
| R. A. Triangle.   | B, *a*. | C, *b*, *c*. | $C=90°-B$ $b=\frac{a\times\sin B}{R}$; $c=\frac{a\times\cos B}{R}$ |
| | B, *b*. | C, *a*, *c*. | $C=90°-B$; $a=\frac{R\times b}{\sin B}$; $c=\frac{R\times b}{\tan B}$ |
| | *b*, *c*. | B, C, *a*. | $\tan B=\frac{R\times b}{c}$; $\cot C=\frac{R\times b}{c}$ $a=\frac{R\times b}{\sin B}$ or $a=\sqrt{b^2+c^2}$ |
| | *a*, *b*. | B, C, *c*. | $\sin B=\frac{R\times b}{a}$; $\cos C=\frac{R\times b}{a}$ $c=\frac{a\times\sin C}{R}$ or $c=\sqrt{a^2-b^2}$ |
| Triangle.   | A, B, *a*. | C, *b*, *c*. | $C=180°-(A+B)$; $b=\frac{a\times\sin B}{\sin A}$; $c=\frac{a\times\sin C}{\sin A}$ |
| | A, *a*, *b*. | B, C, *c*. | $\sin B=\frac{b\times\sin A}{a}$ $C=180-(A+B)$; $c=\frac{a\times\sin C}{\sin A}$ |
| | A, *b*, *c*. | B, C, *a*. | $\tan\frac{1}{2}(B-C)=\frac{b-c}{b+c}\tan\frac{1}{2}(B+C)$ $B=\frac{1}{2}(B+C)+\frac{1}{2}(B-C)$ $C=\frac{1}{2}(B+C)-\frac{1}{2}(B-C)$ $a=\frac{b\times\sin A}{\sin B}$ |
| | *a*, *b*, *c*. | A, B, C, | $\sin\frac{1}{2}A=\sqrt{\frac{R^2(s-b)(s-c)}{b\times c}}$ $s=\frac{1}{2}(a+b+c)$ |

## AREAS AND CONTENTS.

| | |
|---|---|
| Triangle. | Area = ½base × altitude |
| | $\text{Area} = \frac{1}{2}\frac{b \times c \times \sin A}{R}$ |
| | $\text{Area} = \sqrt{s(s-a)(s-b)(s-c)},\ s = \frac{1}{2}(a+b+c)$ |
| Parallelogram. | Area = base × altitude |
| | $\text{Area} = \frac{\text{product of two sides} \times \text{sine of included angle}}{R}$ |
| Trapezoid. | Area = ½ sum of parallel sides × altitude |
| Quadrilateral. | $\text{Area} = \frac{\text{product of diagonals} \times \text{sine of included angle}}{R}$ |
| Circle. | Circumference = $2\pi r$ |
| $r$ = radius | $\text{Diameter} = \frac{\text{circumference}}{\pi}$ |
| $\pi$=3.141593 | |
| | $\text{Length of an arc} = \frac{2\pi r}{360} \times$ No. of degrees |
| | Area = $\pi \times r^2$ |
| | $\text{Area of sector} = \frac{\pi r^2}{360} \times$ No. of degrees |
| | Area of segment = sector − triangle |
| | Area of ring = $\pi(R^2 - r^2)$ |
| Ellipse. | Area = $\pi ab$, in which $a$ and $b$ are the semi-axes. |
| Parabola. | Area = ⅔ base × height = ⅔ $bh$ |
| Right Prism. | Convex surface = perimeter × altitude = P × $h$ |
| | Contents = area of base × altitude = A × $h$ |
| Regular Pyramid. | Convex surface = ½ perimeter × slant height = ½P × $l$ |
| | Contents = ⅓ area of base × altitude = ⅓ A × $h$ |
| Frustum of a Regular Pyramid. | Convex surface = ½ sum of perimeters of bases × slant height = ½ (P + P′) × $l$ |
| | Contents = ⅓ alt. × sum of upper base, lower base and a mean proportional = ⅓ $b$ (A + A′ + $\sqrt{A \cdot A'}$) |
| Cylinder. | Convex surface = circumference × alt. = $2\pi r \times h$ |
| | Contents = area of base × altitude = $\pi r^2 \times h$ |
| Cone. | Convex surface = ½ circumf. × slant height = $\pi r l$ |
| | Contents = ⅓ area of base × altitude = ⅓ $\pi r^2 h$ |
| Frustum of Cone. | Convex surface = ½ sum of circumferences × slant height = $\pi(r + r') \times l$ |
| | Contents = ⅓ alt. × (upper base + lower base + mean proportional) = ⅓ $h\pi(r^2 + r'^2 + rr')$ |
| Sphere. | Surface = $\pi \times$ square of diameter = $4\pi r^2$ |
| | Contents = ⅙ $\pi \times$ cube of diameter = ⅘ $\pi r^3$ |

MISCELLANEOUS FORMULÆ.

| | |
|---|---|
| Falling Bodies. | $s$ = space described $= \frac{1}{2} g t^2 = \frac{v^2}{2g}$ |
| $g = 32.170$ ft. | $v$ = velocity acquired $= gt = \frac{2s}{t} = \sqrt{2gs}$ |
| | $t$ = time, in seconds $= \frac{v}{g} = \sqrt{\frac{2s}{g}}$ |
| Discharge of Liquids. | Velocity per second $= \sqrt{2gh}$ |
| | Quantity per second (theoretical) $= A\sqrt{2gh}$ |
| | Quantity per second (actual) $= \frac{2}{3} A\sqrt{2gh}$ |
| | $A$ = area of orifice |
| | $h$ = depth of orifice below the surface |
| Strength of Beams. | Supported at one end: |
| | $W = \frac{sbd^2}{2l}$ (rectangular) |
| | $W = \frac{\pi s r^3}{l}$ (cylindrical) |
| | Supported at both ends: |
| | $W = \frac{2sbd^2}{l}$ (rectangular) |
| | $W = \frac{4\pi s r^3}{l}$ (cylindrical). |
| | $s$ = tensile strength for each unit of area |
| | $l$ = length; $b$ = breadth; $d$ = depth |
| | W = breaking weight |
| Projectile. | Range $= \frac{v^2 \sin 2a}{g}$ |
| | $v$ = initial velocity |
| | $a$ = angle of elevation |

# TABLE II.

## USEFUL NUMBERS AND THEIR LOGARITHMS.

| NAMES. | NUMBERS. | LOGS. |
|---|---|---|
| Ratio of circumference of circle to diameter, $\pi$ | 3.1415926 | 0.497150 |
| Ratio of diameter of circle to circumference, $\frac{1}{\pi}$ | 0.318310 | 1.502850 |
| Force of gravity in feet, at lat. 45° . . . $g_{45}$ | 32.17076 | 1.507461 |
| Length of seconds' pendulum in inches, lat. 45° . . . $l_{45}$ | 39.1156 | 1.592349 |
| Equatorial radius of earth in miles . . . . . $a$ | 3,962.80 | 3.598002 |
| Polar radius of earth in miles . . . . . $b$ | 3,949.55 | 3.596548 |
| Radius of earth as a sphere, in miles . . . . | 3,958. | 3.597476 |
| Mean length of a degree on meridian, in miles | 69.048 | 1.839151 |
| Length of a degree of longitude, lat. 30° | 59.944 | 1.777746 |
| Length of a degree of longitude, lat. 35° | 56.715 | 1.753698 |
| Length of a degree of longitude, lat. 40° | 53.053 | 1.724710 |
| Length of a degree of longitude, lat. 45° | 48.986 | 1.690072 |
| Distance of the sun in miles | 91,328,000 | 7.960604 |
| Tropical year, in mean solar days | 365.2422 | 2.562581 |
| Statute mile, in feet | 5,280 | 3.722634 |
| Statute mile, in metres | 1,609.41 | 3.206667 |
| Gallon, in cubic inches | 231 | 2.363612 |
| French metre, in feet | 3.280869 | 0.515989 |
| French metre, in inches | 39.370432 | 1.595170 |
| French gramme, in grains | 15.432349 | 1.188432 |
| Velocity of light per second, in miles | 185,000 | 5.267172 |
| Velocity per second of sound in air 32°, in feet | 1,090 | 3.037427 |
| Increase in velocity for each 1° rise in temperature | 0.96 | |
| One-horse power, or number of pounds raised 1 foot in 1 minute | 33,000 | 4.518514 |
| Mechanical equivalent of heat (foot-pound) | 772 | 2.887617 |

USEFUL NUMBERS—*Continued.*

| SUBSTANCES. | SPECIFIC GRAVITY. | WT. PER CUBIC FOOT. | TENSION PER SQ. INCH. |
|---|---|---|---|
| *Metals.* | | | |
| Brass | 7.820 | 488.75 | 42,000 |
| Copper, cast | 8.788 | 549.25 | 24,250 |
| Copper wire | 8.880 | 555.00 | 61,200 |
| Iron, mean American | 7.690 | 590.62 | 31,829 |
| Iron, best Swedish bar | 7.800 | 487.50 | 72,000 |
| Platinum wire | 20.337 | 1271.06 | 53,000 |
| Steel, cast, mean | 7.833 | 489.61 | 88,657 |
| Tin, cast | 7.390 | 461.82 | 5,000 |
| Zinc | 6.861 | 428.81 | 3,500 |
| Wire ropes | | | 37,000 |
| *Timbers.* | | | |
| Ash | 0.760 | 47.500 | 17,000 |
| Cedar | 0.561 | 35.060 | 11,400 |
| Elm | 0.540 | 33.750 | 13,400 |
| Locust | 0.950 | 59.375 | 20,500 |
| Maple | 0.637 | 39.503 | 10,500 |
| Oak | 0.687 | 42.937 | 11,500 |
| Pine, red | 0.660 | 41.250 | 10,000 |
| Pine, American white | 0.455 | 28.438 | 11,800 |
| Spruce | 0.500 | 31.250 | 10,298 |
| Walnut | 0.671 | 41.937 | 17,800 |
| *Building Material.* | | | |
| Bluestone | 2 688 | 168.00 | |
| Brick, average | 1.900 | 118.75 | |
| Granite, Quincy | 2.652 | 165.75 | |
| Limestone | 3.156 | 197.25 | |
| Marble, Italian | 2.708 | 169.25 | |
| Sandstone | 2.200 | 137.50 | |
| Trap | 2.720 | 170.00 | |

A

# TABLE,

CONTAINING

## THE LOGARITHMS OF NUMBERS

FROM 1 TO 10,000.

---

### NUMBERS FROM 1 TO 100 AND THEIR LOGARITHMS,

WITH THEIR INDICES.

| No. | Logarithm. | No. | Logarithm. | No. | Logarithm. | No. | Logarithm. | No. | Logarithm. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0·000000 | 21 | 1·322219 | 41 | 1·612784 | 61 | 1·785330 | 81 | 1·908485 |
| 2 | 0·301030 | 22 | 1·342423 | 42 | 1·623249 | 62 | 1·792392 | 82 | 1·913814 |
| 3 | 0·477121 | 23 | 1·361728 | 43 | 1·633468 | 63 | 1·799341 | 83 | 1·919078 |
| 4 | 0·602060 | 24 | 1·380211 | 44 | 1·643453 | 64 | 1·806180 | 84 | 1·924279 |
| 5 | 0·698970 | 25 | 1·397940 | 45 | 1·653213 | 65 | 1·812913 | 85 | 1·929419 |
| 6 | 0·778151 | 26 | 1·414973 | 46 | 1·662758 | 66 | 1·819544 | 86 | 1·934498 |
| 7 | 0·845098 | 27 | 1·431364 | 47 | 1·672098 | 67 | 1·826075 | 87 | 1·939519 |
| 8 | 0·903090 | 28 | 1·447158 | 48 | 1·681241 | 68 | 1·832509 | 88 | 1·944483 |
| 9 | 0·954243 | 29 | 1·462398 | 49 | 1·690196 | 69 | 1·838849 | 89 | 1·949390 |
| 10 | 1·000000 | 30 | 1·477121 | 50 | 1·698970 | 70 | 1·845098 | 90 | 1·954243 |
| 11 | 1·041393 | 31 | 1·491362 | 51 | 1·707570 | 71 | 1·851258 | 91 | 1·959041 |
| 12 | 1·079181 | 32 | 1·505150 | 52 | 1·716003 | 72 | 1·857332 | 92 | 1·963788 |
| 13 | 1·113943 | 33 | 1·518514 | 53 | 1·724276 | 73 | 1·863323 | 93 | 1·968483 |
| 14 | 1·146128 | 34 | 1·531479 | 54 | 1·732394 | 74 | 1·869232 | 94 | 1·973128 |
| 15 | 1·176091 | 35 | 1·544068 | 55 | 1·740363 | 75 | 1·875061 | 95 | 1·977724 |
| 16 | 1·204120 | 36 | 1·556303 | 56 | 1·748188 | 76 | 1·880814 | 96 | 1·982271 |
| 17 | 1·230449 | 37 | 1·568202 | 57 | 1·755875 | 77 | 1·886491 | 97 | 1·986772 |
| 18 | 1·255273 | 38 | 1·579784 | 58 | 1·763428 | 78 | 1·892095 | 98 | 1·991226 |
| 19 | 1·278754 | 39 | 1·591065 | 59 | 1·770852 | 79 | 1·897627 | 99 | 1·995635 |
| 20 | 1·301030 | 40 | 1·602060 | 60 | 1·778151 | 80 | 1·903090 | 100 | 2·000000 |

NOTE.—In the following part of the Table, the Indices are omitted, as they can be very easily supplied. Thus, the index of the logarithm of every integer number, consisting only of one number, is 0; of two figures, 1; of three figures, 2; of four figures, 3: being always a unit less than the number of figures contained in the integer number. The index to the logarithm of every number above 100, in the following part of the Table, is omitted; yet, in the operation, it must be prefixed, according to this remark: so that the logarithm of 600 is 2·77815, and that of 6000 is 3·77815, and so of the rest.

| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 000000 | 000434 | 000868 | 001301 | 001734 | 002166 | 002598 | 003029 | 003461 | 003891 | 432 |
| 1 | 4321 | 4751 | 5181 | 5609 | 6038 | 6466 | 6894 | 7321 | 7748 | 8174 | 428 |
| 2 | 8600 | 9026 | 9451 | 9876 | 010300 | 010724 | 011147 | 011570 | 011993 | 012415 | 424 |
| 3 | 012837 | 013259 | 013680 | 014100 | 4521 | 4940 | 5360 | 5779 | 6197 | 6616 | 420 |
| 4 | 7033 | 7451 | 7868 | 8284 | 8700 | 9116 | 9532 | 9947 | 020361 | 020775 | 416 |
| 5 | 021189 | 021603 | 022016 | 022428 | 022841 | 023252 | 023664 | 024075 | 4486 | 4896 | 412 |
| 6 | 5306 | 5715 | 6125 | 6533 | 6942 | 7350 | 7757 | 8164 | 8571 | 8978 | 408 |
| 7 | 9384 | 9789 | 030195 | 030600 | 031004 | 031408 | 031812 | 032216 | 032619 | 033021 | 404 |
| 8 | 033424 | 033826 | 4227 | 4628 | 5029 | 5430 | 5830 | 6230 | 6629 | 7028 | 400 |
| 9 | 7426 | 7825 | 8223 | 8620 | 9017 | 9414 | 9811 | 040207 | 040602 | 040998 | 397 |
| 110 | 041393 | 041787 | 042182 | 042576 | 042969 | 043362 | 043755 | 044148 | 044540 | 044932 | 393 |
| 1 | 5323 | 5714 | 6105 | 6495 | 6885 | 7275 | 7664 | 8053 | 8442 | 8830 | 390 |
| 2 | 9218 | 9606 | 9993 | 050380 | 050766 | 051153 | 051538 | 051924 | 052309 | 052694 | 386 |
| 3 | 053078 | 053463 | 053846 | 4230 | 4613 | 4996 | 5378 | 5760 | 6142 | 6524 | 383 |
| 4 | 6905 | 7286 | 7666 | 8046 | 8426 | 8805 | 9185 | 9563 | 9942 | 060320 | 379 |
| 5 | 060698 | 061075 | 061452 | 061829 | 062206 | 062582 | 062958 | 063333 | 063709 | 4083 | 376 |
| 6 | 4458 | 4832 | 5206 | 5580 | 5953 | 6326 | 6699 | 7071 | 7443 | 7815 | 373 |
| 7 | 8186 | 8557 | 8928 | 9298 | 9668 | 070038 | 070407 | 070776 | 071145 | 071514 | 370 |
| 8 | 071882 | 072250 | 072617 | 072985 | 073352 | 3718 | 4085 | 4451 | 4816 | 5182 | 366 |
| 9 | 5547 | 5912 | 6276 | 6640 | 7004 | 7368 | 7731 | 8094 | 8457 | 8819 | 363 |
| 120 | 079181 | 079543 | 079904 | 080266 | 080626 | 080987 | 081347 | 081707 | 082067 | 082426 | 360 |
| 1 | 082785 | 083144 | 083503 | 3861 | 4219 | 4576 | 4934 | 5291 | 5647 | 6004 | 357 |
| 2 | 6360 | 6716 | 7071 | 7426 | 7781 | 8136 | 8490 | 8845 | 9198 | 9552 | 355 |
| 3 | 9905 | 090258 | 090611 | 090963 | 091315 | 091667 | 092018 | 092370 | 092721 | 093071 | 352 |
| 4 | 093422 | 3772 | 4122 | 4471 | 4820 | 5169 | 5518 | 5866 | 6215 | 6562 | 349 |
| 5 | 6910 | 7257 | 7604 | 7951 | 8298 | 8644 | 8990 | 9335 | 9681 | 100026 | 346 |
| 6 | 100371 | 100715 | 101059 | 101403 | 101747 | 102091 | 102434 | 102777 | 103119 | 3462 | 343 |
| 7 | 3804 | 4146 | 4487 | 4828 | 5169 | 5510 | 5851 | 6191 | 6531 | 6871 | 341 |
| 8 | 7210 | 7549 | 7888 | 8227 | 8565 | 8903 | 9241 | 9579 | 9916 | 110253 | 338 |
| 9 | 110590 | 110926 | 111263 | 111599 | 111934 | 112270 | 112605 | 112940 | 113275 | 3609 | 335 |
| 130 | 113943 | 114277 | 114611 | 114944 | 115278 | 115611 | 115943 | 116276 | 116608 | 116940 | 333 |
| 1 | 7271 | 7603 | 7934 | 8265 | 8595 | 8926 | 9256 | 9586 | 9915 | 120245 | 330 |
| 2 | 120574 | 120903 | 121231 | 121560 | 121888 | 122216 | 122544 | 122871 | 123198 | 3525 | 328 |
| 3 | 3852 | 4178 | 4504 | 4830 | 5156 | 5481 | 5806 | 6131 | 6456 | 6781 | 325 |
| 4 | 7105 | 7429 | 7753 | 8076 | 8399 | 8722 | 9045 | 9368 | 9690 | 130012 | 323 |
| 5 | 130334 | 130655 | 130977 | 131298 | 131619 | 131939 | 132260 | 132580 | 132900 | 3219 | 321 |
| 6 | 3539 | 3858 | 4177 | 4496 | 4814 | 5133 | 5451 | 5769 | 6086 | 6403 | 318 |
| 7 | 6721 | 7037 | 7354 | 7671 | 7987 | 8303 | 8618 | 8934 | 9249 | 9564 | 316 |
| 8 | 9879 | 140194 | 140508 | 140822 | 141136 | 141450 | 141763 | 142076 | 142389 | 142702 | 314 |
| 9 | 143015 | 3327 | 3639 | 3951 | 4263 | 4574 | 4885 | 5196 | 5507 | 5818 | 311 |
| 140 | 146128 | 146438 | 146748 | 147058 | 147367 | 147676 | 147985 | 148294 | 148603 | 148911 | 309 |
| 1 | 9219 | 9527 | 9835 | 150142 | 150449 | 150756 | 151063 | 151370 | 151676 | 151982 | 307 |
| 2 | 152288 | 152594 | 152900 | 3205 | 3510 | 3815 | 4120 | 4424 | 4728 | 5032 | 305 |
| 3 | 5336 | 5640 | 5943 | 6246 | 6549 | 6852 | 7154 | 7457 | 7759 | 8061 | 303 |
| 4 | 8362 | 8664 | 8965 | 9266 | 9567 | 9868 | 160168 | 160469 | 160769 | 161068 | 301 |
| 5 | 161368 | 161667 | 161967 | 162266 | 162564 | 162863 | 3161 | 3460 | 3758 | 4055 | 299 |
| 6 | 4353 | 4650 | 4947 | 5244 | 5541 | 5838 | 6134 | 6430 | 6726 | 7022 | 297 |
| 7 | 7317 | 7613 | 7908 | 8203 | 8497 | 8792 | 9086 | 9380 | 9674 | 9968 | 295 |
| 8 | 170262 | 170555 | 170848 | 171141 | 171434 | 171726 | 172019 | 172311 | 172603 | 172895 | 293 |
| 9 | 3186 | 3478 | 3769 | 4060 | 4351 | 4641 | 4932 | 5222 | 5512 | 5802 | 291 |
| 150 | 176091 | 176381 | 176670 | 176959 | 177248 | 177536 | 177825 | 178113 | 178401 | 178689 | 289 |
| 1 | 8977 | 9264 | 9552 | 9839 | 180126 | 180413 | 180699 | 180986 | 181272 | 181558 | 287 |
| 2 | 181844 | 182129 | 182415 | 182700 | 2985 | 3270 | 3555 | 3839 | 4123 | 4407 | 285 |
| 3 | 4691 | 4975 | 5259 | 5542 | 5825 | 6108 | 6391 | 6674 | 6956 | 7239 | 283 |
| 4 | 7521 | 7803 | 8084 | 8366 | 8647 | 8928 | 9209 | 9490 | 9771 | 190051 | 281 |
| 5 | 190332 | 190612 | 190892 | 191171 | 191451 | 191730 | 192010 | 192289 | 192567 | 2846 | 279 |
| 6 | 3125 | 3403 | 3681 | 3959 | 4237 | 4514 | 4792 | 5069 | 5346 | 5623 | 278 |
| 7 | 5900 | 6176 | 6453 | 6729 | 7005 | 7281 | 7556 | 7832 | 8107 | 8382 | 276 |
| 8 | 8657 | 8932 | 9206 | 9481 | 9755 | 200029 | 200303 | 200577 | 200850 | 201124 | 274 |
| 9 | 201397 | 201670 | 201943 | 202216 | 202488 | 2761 | 3033 | 3305 | 3577 | 3848 | 272 |
| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Diff. |

| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 160 | 204120 | 204391 | 204663 | 204934 | 205204 | 205475 | 205746 | 206016 | 206286 | 206556 | 271 |
| 1 | 6826 | 7096 | 7365 | 7634 | 7904 | 8173 | 8441 | 8710 | 8979 | 9247 | 269 |
| 2 | 9515 | 9783 | 210051 | 210319 | 210586 | 210853 | 211121 | 211388 | 211654 | 211921 | 267 |
| 3 | 212188 | 212454 | 2720 | 2986 | 3252 | 3518 | 3783 | 4049 | 4314 | 4579 | 266 |
| 4 | 4844 | 5109 | 5373 | 5638 | 5902 | 6166 | 6430 | 6694 | 6957 | 7221 | 264 |
| 5 | 7484 | 7747 | 8010 | 8273 | 8536 | 8798 | 9060 | 9323 | 9585 | 9846 | 262 |
| 6 | 220108 | 220370 | 220631 | 220892 | 221153 | 221414 | 221675 | 221936 | 222196 | 222456 | 261 |
| 7 | 2716 | 2976 | 3236 | 3496 | 3755 | 4015 | 4274 | 4533 | 4792 | 5051 | 259 |
| 8 | 5309 | 5568 | 5826 | 6084 | 6342 | 6600 | 6858 | 7115 | 7372 | 7630 | 258 |
| 9 | 7887 | 8144 | 8400 | 8657 | 8913 | 9170 | 9426 | 9682 | 9938 | 230193 | 256 |
| 170 | 230449 | 230704 | 230960 | 231215 | 231470 | 231724 | 231979 | 232234 | 232488 | 232742 | 255 |
| 1 | 2996 | 3250 | 3504 | 3757 | 4011 | 4264 | 4517 | 4770 | 5023 | 5276 | 253 |
| 2 | 5528 | 5781 | 6033 | 6285 | 6537 | 6789 | 7041 | 7292 | 7544 | 7795 | 252 |
| 3 | 8046 | 8297 | 8548 | 8799 | 9049 | 9299 | 9550 | 9800 | 240050 | 240300 | 250 |
| 4 | 240549 | 240799 | 241048 | 241297 | 241546 | 241795 | 242044 | 242293 | 2541 | 2790 | 249 |
| 5 | 3038 | 3286 | 3534 | 3782 | 4030 | 4277 | 4525 | 4772 | 5019 | 5266 | 248 |
| 6 | 5513 | 5759 | 6006 | 6252 | 6499 | 6745 | 6991 | 7237 | 7482 | 7728 | 246 |
| 7 | 7973 | 8219 | 8464 | 8709 | 8954 | 9198 | 9443 | 9687 | 9932 | 250176 | 245 |
| 8 | 250420 | 250664 | 250908 | 251151 | 251395 | 251638 | 251881 | 252125 | 252368 | 2610 | 243 |
| 9 | 2853 | 3096 | 3338 | 3580 | 3822 | 4064 | 4306 | 4548 | 4790 | 5031 | 242 |
| 180 | 255273 | 255514 | 255755 | 255996 | 256237 | 256477 | 256718 | 256958 | 257198 | 257439 | 241 |
| 1 | 7679 | 7918 | 8158 | 8398 | 8637 | 8877 | 9116 | 9355 | 9594 | 9833 | 239 |
| 2 | 260071 | 260310 | 260548 | 260787 | 261025 | 261263 | 261501 | 261739 | 261976 | 262214 | 238 |
| 3 | 2451 | 2688 | 2925 | 3162 | 3399 | 3636 | 3873 | 4109 | 4346 | 4582 | 237 |
| 4 | 4818 | 5054 | 5290 | 5525 | 5761 | 5996 | 6232 | 6467 | 6702 | 6937 | 235 |
| 5 | 7172 | 7406 | 7641 | 7875 | 8110 | 8344 | 8578 | 8812 | 9046 | 9279 | 234 |
| 6 | 9513 | 9746 | 9980 | 270213 | 270446 | 270679 | 270912 | 271144 | 271377 | 271609 | 233 |
| 7 | 271842 | 272074 | 272306 | 2538 | 2770 | 3001 | 3233 | 3464 | 3696 | 3927 | 232 |
| 8 | 4158 | 4389 | 4620 | 4850 | 5081 | 5311 | 5542 | 5772 | 6002 | 6232 | 230 |
| 9 | 6462 | 6692 | 6921 | 7151 | 7380 | 7609 | 7838 | 8067 | 8296 | 8525 | 229 |
| 190 | 278754 | 278982 | 279211 | 279439 | 279667 | 279895 | 280123 | 280351 | 280578 | 280806 | 228 |
| 1 | 281033 | 281261 | 281488 | 281715 | 281942 | 282169 | 2396 | 2622 | 2849 | 3075 | 227 |
| 2 | 3301 | 3527 | 3753 | 3979 | 4205 | 4431 | 4656 | 4882 | 5107 | 5332 | 226 |
| 3 | 5557 | 5782 | 6007 | 6232 | 6456 | 6681 | 6905 | 7130 | 7354 | 7578 | 225 |
| 4 | 7802 | 8026 | 8249 | 8473 | 8696 | 8920 | 9143 | 9366 | 9589 | 9812 | 223 |
| 5 | 290035 | 290257 | 290480 | 290702 | 290925 | 291147 | 291369 | 291591 | 291813 | 292034 | 222 |
| 6 | 2256 | 2478 | 2699 | 2920 | 3141 | 3363 | 3584 | 3804 | 4025 | 4246 | 221 |
| 7 | 4466 | 4687 | 4907 | 5127 | 5347 | 5567 | 5787 | 6007 | 6226 | 6446 | 220 |
| 8 | 6665 | 6884 | 7104 | 7323 | 7542 | 7761 | 7979 | 8198 | 8416 | 8635 | 219 |
| 9 | 8853 | 9071 | 9289 | 9507 | 9725 | 9943 | 300161 | 300378 | 300595 | 300813 | 218 |
| 200 | 301030 | 301247 | 301464 | 301681 | 301898 | 302114 | 302331 | 302547 | 302764 | 302980 | 217 |
| 1 | 3196 | 3412 | 3628 | 3844 | 4059 | 4275 | 4491 | 4706 | 4921 | 5136 | 216 |
| 2 | 5351 | 5566 | 5781 | 5996 | 6211 | 6425 | 6639 | 6854 | 7068 | 7282 | 215 |
| 3 | 7496 | 7710 | 7924 | 8137 | 8351 | 8564 | 8778 | 8991 | 9204 | 9417 | 213 |
| 4 | 9630 | 9843 | 310056 | 310268 | 310481 | 310693 | 310906 | 311118 | 311330 | 311542 | 212 |
| 5 | 311754 | 311966 | 2177 | 2389 | 2600 | 2812 | 3023 | 3234 | 3445 | 3656 | 211 |
| 6 | 3867 | 4078 | 4289 | 4499 | 4710 | 4920 | 5130 | 5340 | 5551 | 5760 | 210 |
| 7 | 5970 | 6180 | 6390 | 6599 | 6809 | 7018 | 7227 | 7436 | 7646 | 7854 | 209 |
| 8 | 8063 | 8272 | 8481 | 8689 | 8898 | 9106 | 9314 | 9522 | 9730 | 9938 | 208 |
| 9 | 320146 | 320354 | 320562 | 320769 | 320977 | 321184 | 321391 | 321598 | 321805 | 322012 | 207 |
| 210 | 322219 | 322426 | 322633 | 322839 | 323046 | 323252 | 323458 | 323665 | 323871 | 324077 | 206 |
| 1 | 4282 | 4488 | 4694 | 4899 | 5105 | 5310 | 5516 | 5721 | 5926 | 6131 | 205 |
| 2 | 6336 | 6541 | 6745 | 6950 | 7155 | 7359 | 7563 | 7767 | 7972 | 8176 | 204 |
| 3 | 8380 | 8583 | 8787 | 8991 | 9194 | 9398 | 9601 | 9805 | 330008 | 330211 | 203 |
| 4 | 330414 | 330617 | 330819 | 331022 | 331225 | 331427 | 331630 | 331832 | 2034 | 2236 | 202 |
| 5 | 2438 | 2640 | 2842 | 3044 | 3246 | 3447 | 3649 | 3850 | 4051 | 4253 | 202 |
| 6 | 4454 | 4655 | 4856 | 5057 | 5257 | 5458 | 5658 | 5859 | 6059 | 6260 | 201 |
| 7 | 6460 | 6660 | 6860 | 7060 | 7260 | 7459 | 7659 | 7858 | 8058 | 8257 | 200 |
| 8 | 8456 | 8656 | 8855 | 9054 | 9253 | 9451 | 9650 | 9849 | 340047 | 340246 | 199 |
| 9 | 340444 | 340642 | 340841 | 341039 | 341237 | 341435 | 341632 | 341830 | 2028 | 2225 | 198 |
| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Diff. |

| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 220 | 342423 | 342620 | 342817 | 343014 | 343212 | 343409 | 343606 | 343802 | 343999 | 344196 | 197 |
| 1 | 4392 | 4589 | 4785 | 4981 | 5178 | 5374 | 5570 | 5766 | 5962 | 6157 | 196 |
| 2 | 6353 | 6549 | 6744 | 6939 | 7135 | 7330 | 7525 | 7720 | 7915 | 8110 | 195 |
| 3 | 8305 | 8500 | 8694 | 8889 | 9083 | 9278 | 9472 | 9666 | 9860 | 350054 | 194 |
| 4 | 350248 | 350442 | 350636 | 350829 | 351023 | 351216 | 351410 | 351603 | 351796 | 1989 | 193 |
| 5 | 2183 | 2375 | 2568 | 2761 | 2954 | 3147 | 3339 | 3532 | 3724 | 3916 | 193 |
| 6 | 4108 | 4301 | 4493 | 4685 | 4876 | 5068 | 5260 | 5452 | 5643 | 5834 | 192 |
| 7 | 6026 | 6217 | 6408 | 6599 | 6790 | 6981 | 7172 | 7363 | 7554 | 7744 | 191 |
| 8 | 7935 | 8125 | 8316 | 8506 | 8696 | 8886 | 9076 | 9266 | 9456 | 9646 | 190 |
| 9 | 9835 | 360025 | 360215 | 360404 | 360593 | 360783 | 360972 | 361161 | 361350 | 361539 | 189 |
| 230 | 361728 | 361917 | 362105 | 362294 | 362482 | 362671 | 362859 | 363048 | 363236 | 363424 | 188 |
| 1 | 3612 | 3800 | 3988 | 4176 | 4363 | 4551 | 4739 | 4926 | 5113 | 5301 | 188 |
| 2 | 5488 | 5675 | 5862 | 6049 | 6236 | 6423 | 6610 | 6796 | 6983 | 7169 | 187 |
| 3 | 7356 | 7542 | 7729 | 7915 | 8101 | 8287 | 8473 | 8659 | 8845 | 9030 | 186 |
| 4 | 9216 | 9401 | 9587 | 9772 | 9958 | 370143 | 370328 | 370513 | 370698 | 370883 | 185 |
| 5 | 371068 | 371253 | 371437 | 371622 | 371806 | 1991 | 2175 | 2360 | 2544 | 2728 | 184 |
| 6 | 2912 | 3096 | 3280 | 3464 | 3647 | 3831 | 4015 | 4198 | 4382 | 4565 | 184 |
| 7 | 4748 | 4932 | 5115 | 5298 | 5481 | 5664 | 5846 | 6029 | 6212 | 6394 | 183 |
| 8 | 6577 | 6759 | 6942 | 7124 | 7306 | 7488 | 7670 | 7852 | 8034 | 8216 | 182 |
| 9 | 8398 | 8580 | 8761 | 8943 | 9124 | 9306 | 9487 | 9668 | 9849 | 380030 | 181 |
| 240 | 380211 | 380392 | 380573 | 380754 | 380934 | 381115 | 381296 | 381476 | 381656 | 381837 | 181 |
| 1 | 2017 | 2197 | 2377 | 2557 | 2737 | 2917 | 3097 | 3277 | 3456 | 3636 | 180 |
| 2 | 3815 | 3995 | 4174 | 4353 | 4533 | 4712 | 4891 | 5070 | 5249 | 5428 | 179 |
| 3 | 5606 | 5785 | 5964 | 6142 | 6321 | 6499 | 6677 | 6856 | 7034 | 7212 | 178 |
| 4 | 7390 | 7568 | 7746 | 7923 | 8101 | 8279 | 8456 | 8634 | 8811 | 8989 | 178 |
| 5 | 9166 | 9343 | 9520 | 9698 | 9875 | 390051 | 390228 | 390405 | 390582 | 390759 | 177 |
| 6 | 390935 | 391112 | 391288 | 391464 | 391641 | 1817 | 1993 | 2169 | 2345 | 2521 | 176 |
| 7 | 2697 | 2873 | 3048 | 3224 | 3400 | 3575 | 3751 | 3926 | 4101 | 4277 | 176 |
| 8 | 4452 | 4627 | 4802 | 4977 | 5152 | 5326 | 5501 | 5676 | 5850 | 6025 | 175 |
| 9 | 6199 | 6374 | 6548 | 6722 | 6896 | 7071 | 7245 | 7419 | 7592 | 7766 | 174 |
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| 2 | 401401 | 401573 | 1745 | 1917 | 2089 | 2261 | 2433 | 2605 | 2777 | 2949 | 172 |
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| 6 | 8240 | 8410 | 8579 | 8749 | 8918 | 9087 | 9257 | 9426 | 9595 | 9764 | 169 |
| 7 | 9933 | 410102 | 410271 | 410440 | 410609 | 410777 | 410946 | 411114 | 411283 | 411451 | 169 |
| 8 | 411620 | 1788 | 1956 | 2124 | 2293 | 2461 | 2629 | 2796 | 2964 | 3132 | 168 |
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| 3 | 9956 | 420121 | 420286 | 420451 | 420616 | 420781 | 420945 | 421110 | 421275 | 421439 | 165 |
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| 6 | 4882 | 5045 | 5208 | 5371 | 5534 | 5697 | 5860 | 6023 | 6186 | 6349 | 163 |
| 7 | 6511 | 6674 | 6836 | 6999 | 7161 | 7324 | 7486 | 7648 | 7811 | 7973 | 162 |
| 8 | 8135 | 8297 | 8459 | 8621 | 8783 | 8944 | 9106 | 9268 | 9429 | 9591 | 162 |
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| 1 | 2969 | 3130 | 3290 | 3450 | 3610 | 3770 | 3930 | 4090 | 4249 | 4409 | 160 |
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| 7 | 7138 | 7280 | 7421 | 7563 | 7704 | 7845 | 7986 | 8127 | 8269 | 8410 | 141 |
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| 8 | 8917 | 9045 | 9174 | 9302 | 9430 | 9559 | 9687 | 9815 | 9943 | 530072 | 128 |
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| 7 | 4666 | 4784 | 4903 | 5021 | 5139 | 5257 | 5376 | 5494 | 5612 | 5730 | 118 |
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| 9 | 7026 | 7144 | 7262 | 7379 | 7497 | 7614 | 7732 | 7849 | 7967 | 8084 | 118 |
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| 3 | 6098 | 6194 | 6290 | 6386 | 6482 | 6577 | 6673 | 6769 | 6864 | 6960 | 96 |
| 4 | 7056 | 7152 | 7247 | 7343 | 7438 | 7534 | 7629 | 7725 | 7820 | 7916 | 96 |
| 5 | 8011 | 8107 | 8202 | 8298 | 8393 | 8488 | 8584 | 8679 | 8774 | 8870 | 95 |
| 6 | 8965 | 9060 | 9155 | 9250 | 9346 | 9441 | 9536 | 9631 | 9726 | 9821 | 95 |
| 7 | 9916 | 660011 | 660106 | 660201 | 660296 | 660391 | 660486 | 660581 | 660676 | 660771 | 95 |
| 8 | 660865 | 0960 | 1055 | 1150 | 1245 | 1339 | 1434 | 1529 | 1623 | 1718 | 95 |
| 9 | 1813 | 1907 | 2002 | 2096 | 2191 | 2286 | 2380 | 2475 | 2569 | 2663 | 95 |
| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Dif. |

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| 1 | 3701 | 3795 | 3889 | 3983 | 4078 | 4172 | 4266 | 4360 | 4454 | 4548 | 94 |
| 2 | 4642 | 4736 | 4830 | 4924 | 5018 | 5112 | 5206 | 5299 | 5393 | 5487 | 94 |
| 3 | 5581 | 5675 | 5769 | 5862 | 5956 | 6050 | 6143 | 6237 | 6331 | 6424 | 94 |
| 4 | 6518 | 6612 | 6705 | 6799 | 6892 | 6986 | 7079 | 7173 | 7266 | 7360 | 94 |
| 5 | 7453 | 7546 | 7640 | 7733 | 7826 | 7920 | 8013 | 8106 | 8199 | 8293 | 93 |
| 6 | 8386 | 8479 | 8572 | 8665 | 8759 | 8852 | 8945 | 9038 | 9131 | 9224 | 93 |
| 7 | 9317 | 9410 | 9503 | 9596 | 9689 | 9782 | 9875 | 9967 | 670060 | 670153 | 93 |
| 8 | 670246 | 670339 | 670431 | 670524 | 670617 | 670710 | 670802 | 670895 | 0988 | 1080 | 93 |
| 9 | 1173 | 1265 | 1358 | 1451 | 1543 | 1636 | 1728 | 1821 | 1913 | 2005 | 93 |
| 470 | 672098 | 672190 | 672283 | 672375 | 672467 | 672560 | 672652 | 672744 | 672836 | 672929 | 92 |
| 1 | 3021 | 3113 | 3205 | 3297 | 3390 | 3482 | 3574 | 3666 | 3758 | 3850 | 92 |
| 2 | 3942 | 4034 | 4126 | 4218 | 4310 | 4402 | 4494 | 4586 | 4677 | 4769 | 92 |
| 3 | 4861 | 4953 | 5045 | 5137 | 5228 | 5320 | 5412 | 5503 | 5595 | 5687 | 92 |
| 4 | 5778 | 5870 | 5962 | 6053 | 6145 | 6236 | 6328 | 6419 | 6511 | 6602 | 92 |
| 5 | 6694 | 6785 | 6876 | 6968 | 7059 | 7151 | 7242 | 7333 | 7424 | 7516 | 91 |
| 6 | 7607 | 7698 | 7789 | 7881 | 7972 | 8063 | 8154 | 8245 | 8336 | 8427 | 91 |
| 7 | 8518 | 8609 | 8700 | 8791 | 8882 | 8973 | 9064 | 9155 | 9246 | 9337 | 91 |
| 8 | 9428 | 9519 | 9610 | 9700 | 9791 | 9882 | 9973 | 680063 | 680154 | 680245 | 91 |
| 9 | 680336 | 680426 | 680517 | 680607 | 680698 | 680789 | 680879 | 0970 | 1060 | 1151 | 91 |
| 480 | 681241 | 681332 | 681422 | 681513 | 681603 | 681693 | 681784 | 681874 | 681964 | 682055 | 90 |
| 1 | 2145 | 2235 | 2326 | 2416 | 2506 | 2506 | 2686 | 2777 | 2867 | 2957 | 90 |
| 2 | 3047 | 3137 | 3227 | 3317 | 3407 | 3497 | 3587 | 3677 | 3767 | 3857 | 90 |
| 3 | 3947 | 4037 | 4127 | 4217 | 4307 | 4396 | 4486 | 4576 | 4666 | 4756 | 90 |
| 4 | 4845 | 4935 | 5025 | 5114 | 5204 | 5294 | 5383 | 5473 | 5563 | 5652 | 90 |
| 5 | 5742 | 5831 | 5921 | 6010 | 6100 | 6189 | 6279 | 6368 | 6458 | 6547 | 89 |
| 6 | 6636 | 6726 | 6815 | 6904 | 6994 | 7083 | 7172 | 7261 | 7351 | 7440 | 89 |
| 7 | 7529 | 7618 | 7707 | 7796 | 7886 | 7975 | 8064 | 8153 | 8242 | 8331 | 89 |
| 8 | 8420 | 8509 | 8598 | 8687 | 8776 | 8865 | 8953 | 9042 | 9131 | 9220 | 89 |
| 9 | 9309 | 9398 | 9486 | 9575 | 9664 | 9753 | 9841 | 9930 | 690019 | 690107 | 89 |
| 490 | 690196 | 690285 | 690373 | 690462 | 690550 | 690639 | 690728 | 690816 | 690905 | 690993 | 89 |
| 1 | 1081 | 1170 | 1258 | 1347 | 1435 | 1524 | 1612 | 1700 | 1789 | 1877 | 88 |
| 2 | 1965 | 2053 | 2142 | 2230 | 2318 | 2406 | 2494 | 2583 | 2671 | 2759 | 88 |
| 3 | 2847 | 2935 | 3023 | 3111 | 3199 | 3287 | 3375 | 3463 | 3551 | 3639 | 88 |
| 4 | 3727 | 3815 | 3903 | 3991 | 4078 | 4166 | 4254 | 4342 | 4430 | 4517 | 88 |
| 5 | 4605 | 4693 | 4781 | 4868 | 4956 | 5044 | 5131 | 5219 | 5307 | 5394 | 88 |
| 6 | 5482 | 5569 | 5657 | 5744 | 5832 | 5919 | 6007 | 6094 | 6182 | 6269 | 87 |
| 7 | 6356 | 6444 | 6531 | 6618 | 6706 | 6793 | 6880 | 6968 | 7055 | 7142 | 87 |
| 8 | 7229 | 7317 | 7404 | 7491 | 7578 | 7665 | 7752 | 7839 | 7926 | 8014 | 87 |
| 9 | 8101 | 8188 | 8275 | 8362 | 8449 | 8535 | 8622 | 8709 | 8796 | 8883 | 87 |
| 500 | 698970 | 699057 | 699144 | 699231 | 699317 | 699404 | 699491 | 699578 | 699664 | 699751 | 87 |
| 1 | 9838 | 9924 | 700011 | 700098 | 700184 | 700271 | 700358 | 700444 | 700531 | 700617 | 87 |
| 2 | 700704 | 700790 | 0877 | 0963 | 1050 | 1136 | 1222 | 1309 | 1395 | 1482 | 86 |
| 3 | 1568 | 1654 | 1741 | 1827 | 1913 | 1999 | 2086 | 2172 | 2258 | 2344 | 86 |
| 4 | 2431 | 2517 | 2603 | 2689 | 2775 | 2861 | 2947 | 3033 | 3119 | 3205 | 86 |
| 5 | 3291 | 3377 | 3463 | 3549 | 3635 | 3721 | 3807 | 3893 | 3979 | 4065 | 86 |
| 6 | 4151 | 4236 | 4322 | 4408 | 4494 | 4579 | 4665 | 4751 | 4837 | 4922 | 86 |
| 7 | 5008 | 5094 | 5179 | 5265 | 5350 | 5436 | 5522 | 5607 | 5693 | 5778 | 86 |
| 8 | 5864 | 5949 | 6035 | 6120 | 6206 | 6291 | 6376 | 6462 | 6547 | 6632 | 85 |
| 9 | 6718 | 6803 | 6888 | 6974 | 7059 | 7144 | 7229 | 7315 | 7400 | 7485 | 85 |
| 510 | 707570 | 707655 | 707740 | 707826 | 707911 | 707996 | 708081 | 708166 | 708251 | 708336 | 85 |
| 1 | 8421 | 8506 | 8591 | 8676 | 8761 | 8846 | 8931 | 9015 | 9100 | 9185 | 85 |
| 2 | 9270 | 9355 | 9440 | 9524 | 9609 | 9694 | 9779 | 9863 | 9948 | 710033 | 85 |
| 3 | 710117 | 710202 | 710287 | 710371 | 710456 | 710540 | 710625 | 710710 | 710794 | 0879 | 85 |
| 4 | 0963 | 1048 | 1132 | 1217 | 1301 | 1385 | 1470 | 1554 | 1639 | 1723 | 84 |
| 5 | 1807 | 1892 | 1976 | 2060 | 2144 | 2229 | 2313 | 2397 | 2481 | 2566 | 84 |
| 6 | 2650 | 2734 | 2818 | 2902 | 2986 | 3070 | 3154 | 3238 | 3323 | 3407 | 84 |
| 7 | 3491 | 3575 | 3659 | 3742 | 3826 | 3910 | 3994 | 4078 | 4162 | 4246 | 84 |
| 8 | 4330 | 4414 | 4497 | 4581 | 4665 | 4749 | 4833 | 4916 | 5000 | 5084 | 84 |
| 9 | 5167 | 5251 | 5335 | 5418 | 5502 | 5586 | 5669 | 5753 | 5836 | 5920 | 84 |
| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Diff. |

| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Diff. |
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| 1 | 6838 | 6921 | 7004 | 7088 | 7171 | 7254 | 7338 | 7421 | 7504 | 7587 | 83 |
| 2 | 7671 | 7754 | 7837 | 7920 | 8003 | 8086 | 8169 | 8253 | 8336 | 8419 | 83 |
| 3 | 8502 | 8585 | 8668 | 8751 | 8834 | 8917 | 9000 | 9083 | 9165 | 9248 | 83 |
| 4 | 9331 | 9414 | 9497 | 9580 | 9663 | 9745 | 9828 | 9911 | 9994 | 720077 | 83 |
| 5 | 720159 | 720242 | 720325 | 720407 | 720490 | 720573 | 720655 | 720738 | 720821 | 0903 | 83 |
| 6 | 0986 | 1068 | 1151 | 1233 | 1316 | 1398 | 1481 | 1563 | 1646 | 1728 | 82 |
| 7 | 1811 | 1893 | 1975 | 2058 | 2140 | 2222 | 2305 | 2387 | 2469 | 2552 | 82 |
| 8 | 2634 | 2716 | 2798 | 2881 | 2963 | 3045 | 3127 | 3209 | 3291 | 3374 | 82 |
| 9 | 3456 | 3538 | 3620 | 3702 | 3784 | 3866 | 3948 | 4030 | 4112 | 4194 | 82 |
| 530 | 724276 | 724358 | 724440 | 724522 | 724604 | 724685 | 724767 | 724849 | 724931 | 725013 | 82 |
| 1 | 5095 | 5176 | 5258 | 5340 | 5422 | 5503 | 5585 | 5667 | 5748 | 5830 | 82 |
| 2 | 5912 | 5993 | 6075 | 6156 | 6238 | 6320 | 6401 | 6483 | 6564 | 6646 | 82 |
| 3 | 6727 | 6809 | 6890 | 6972 | 7053 | 7134 | 7216 | 7297 | 7379 | 7460 | 81 |
| 4 | 7541 | 7623 | 7704 | 7785 | 7866 | 7948 | 8029 | 8110 | 8191 | 8273 | 81 |
| 5 | 8354 | 8435 | 8516 | 8597 | 8678 | 8759 | 8841 | 8922 | 9003 | 9084 | 81 |
| 6 | 9165 | 9246 | 9327 | 9408 | 9489 | 9570 | 9651 | 9732 | 9813 | 9893 | 81 |
| 7 | 9974 | 730055 | 730136 | 730217 | 730298 | 730378 | 730459 | 730540 | 730621 | 730702 | 81 |
| 8 | 730782 | 0863 | 0944 | 1024 | 1105 | 1186 | 1266 | 1347 | 1428 | 1508 | 81 |
| 9 | 1589 | 1669 | 1750 | 1830 | 1911 | 1991 | 2072 | 2152 | 2233 | 2313 | 81 |
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| 1 | 3197 | 3278 | 3358 | 3438 | 3518 | 3598 | 3679 | 3759 | 3839 | 3919 | 80 |
| 2 | 3999 | 4079 | 4160 | 4240 | 4320 | 4400 | 4480 | 4560 | 4640 | 4720 | 80 |
| 3 | 4800 | 4880 | 4960 | 5040 | 5120 | 5200 | 5279 | 5359 | 5439 | 5519 | 80 |
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| 5 | 6397 | 6476 | 6556 | 6635 | 6715 | 6795 | 6874 | 6954 | 7034 | 7113 | 80 |
| 6 | 7193 | 7272 | 7352 | 7431 | 7511 | 7590 | 7670 | 7749 | 7829 | 7908 | 79 |
| 7 | 7987 | 8067 | 8146 | 8225 | 8305 | 8384 | 8463 | 8543 | 8622 | 8701 | 79 |
| 8 | 8781 | 8860 | 8939 | 9018 | 9097 | 9177 | 9256 | 9335 | 9414 | 9493 | 79 |
| 9 | 9572 | 9651 | 9731 | 9810 | 9889 | 9968 | 740047 | 740126 | 740205 | 740284 | 79 |
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| 1 | 1152 | 1230 | 1309 | 1388 | 1467 | 1546 | 1624 | 1703 | 1782 | 1860 | 79 |
| 2 | 1939 | 2018 | 2096 | 2175 | 2254 | 2332 | 2411 | 2489 | 2568 | 2647 | 79 |
| 3 | 2725 | 2804 | 2882 | 2961 | 3039 | 3118 | 3196 | 3275 | 3353 | 3431 | 78 |
| 4 | 3510 | 3588 | 3667 | 3745 | 3823 | 3902 | 3980 | 4058 | 4136 | 4215 | 78 |
| 5 | 4293 | 4371 | 4449 | 4528 | 4606 | 4684 | 4762 | 4840 | 4919 | 4997 | 78 |
| 6 | 5075 | 5153 | 5231 | 5309 | 5387 | 5465 | 5543 | 5621 | 5699 | 5777 | 78 |
| 7 | 5855 | 5933 | 6011 | 6089 | 6167 | 6245 | 6323 | 6401 | 6479 | 6556 | 78 |
| 8 | 6634 | 6712 | 6790 | 6868 | 6945 | 7023 | 7101 | 7179 | 7256 | 7334 | 78 |
| 9 | 7412 | 7489 | 7567 | 7645 | 7722 | 7800 | 7878 | 7955 | 8033 | 8110 | 78 |
| 560 | 748188 | 748266 | 748343 | 748421 | 748498 | 748576 | 748653 | 748731 | 748808 | 748885 | 77 |
| 1 | 8963 | 9040 | 9118 | 9195 | 9272 | 9350 | 9427 | 9504 | 9582 | 9659 | 77 |
| 2 | 9736 | 9814 | 9891 | 9968 | 750045 | 750123 | 750200 | 750277 | 750354 | 750431 | 77 |
| 3 | 750508 | 750586 | 750663 | 750740 | 0817 | 0894 | 0971 | 1048 | 1125 | 1202 | 77 |
| 4 | 1279 | 1356 | 1433 | 1510 | 1587 | 1664 | 1741 | 1818 | 1895 | 1972 | 77 |
| 5 | 2048 | 2125 | 2202 | 2279 | 2356 | 2433 | 2509 | 2586 | 2663 | 2740 | 77 |
| 6 | 2816 | 2893 | 2970 | 3047 | 3123 | 3200 | 3277 | 3353 | 3430 | 3506 | 77 |
| 7 | 3583 | 3660 | 3736 | 3813 | 3889 | 3966 | 4042 | 4119 | 4195 | 4272 | 77 |
| 8 | 4348 | 4425 | 4501 | 4578 | 4654 | 4730 | 4807 | 4883 | 4960 | 5036 | 76 |
| 9 | 5112 | 5189 | 5265 | 5341 | 5417 | 5494 | 5570 | 5646 | 5722 | 5799 | 76 |
| 570 | 755875 | 755951 | 756027 | 756103 | 756180 | 756256 | 756332 | 756408 | 756484 | 756560 | 76 |
| 1 | 6636 | 6712 | 6788 | 6864 | 6940 | 7016 | 7092 | 7168 | 7244 | 7320 | 76 |
| 2 | 7396 | 7472 | 7548 | 7624 | 7700 | 7775 | 7851 | 7927 | 8003 | 8079 | 76 |
| 3 | 8155 | 8230 | 8306 | 8382 | 8458 | 8533 | 8609 | 8685 | 8761 | 8836 | 76 |
| 4 | 8912 | 8988 | 9063 | 9139 | 9214 | 9290 | 9366 | 9441 | 9517 | 9592 | 76 |
| 5 | 9668 | 9743 | 9819 | 9894 | 9970 | 760045 | 760121 | 760196 | 760272 | 760347 | 75 |
| 6 | 760422 | 760498 | 760573 | 760649 | 760724 | 0799 | 0875 | 0950 | 1025 | 1101 | 75 |
| 7 | 1176 | 1251 | 1326 | 1402 | 1477 | 1552 | 1627 | 1702 | 1778 | 1853 | 75 |
| 8 | 1928 | 2003 | 2078 | 2153 | 2228 | 2303 | 2378 | 2453 | 2529 | 2604 | 75 |
| 9 | 2679 | 2754 | 2829 | 2904 | 2978 | 3053 | 3128 | 3203 | 3278 | 3353 | 75 |
| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Diff. |

| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Dif. |
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| 1 | 4176 | 4251 | 4326 | 4400 | 4475 | 4550 | 4624 | 4699 | 4774 | 4848 | 75 |
| 2 | 4923 | 4998 | 5072 | 5147 | 5221 | 5296 | 5370 | 5445 | 5520 | 5594 | 75 |
| 3 | 5669 | 5743 | 5818 | 5892 | 5966 | 6041 | 6115 | 6190 | 6264 | 6338 | 74 |
| 4 | 6413 | 6487 | 6562 | 6636 | 6710 | 6785 | 6859 | 6933 | 7007 | 7082 | 74 |
| 5 | 7156 | 7230 | 7304 | 7379 | 7453 | 7527 | 7601 | 7675 | 7749 | 7823 | 74 |
| 6 | 7898 | 7972 | 8046 | 8120 | 8194 | 8268 | 8342 | 8416 | 8490 | 8564 | 74 |
| 7 | 8638 | 8712 | 8786 | 8860 | 8934 | 9008 | 9082 | 9156 | 9230 | 9303 | 74 |
| 8 | 9377 | 9451 | 9525 | 9599 | 9673 | 9746 | 9820 | 9894 | 9968 | 770042 | 74 |
| 9 | 770115 | 770189 | 770263 | 770336 | 770410 | 770484 | 770557 | 770631 | 770705 | 0778 | 74 |
| 590 | 770852 | 770926 | 770999 | 771073 | 771146 | 771220 | 771293 | 771367 | 771440 | 771514 | 74 |
| 1 | 1587 | 1661 | 1734 | 1808 | 1881 | 1955 | 2028 | 2102 | 2175 | 2248 | 73 |
| 2 | 2322 | 2395 | 2468 | 2542 | 2615 | 2688 | 2762 | 2835 | 2908 | 2981 | 73 |
| 3 | 3055 | 3128 | 3201 | 3274 | 3348 | 3421 | 3494 | 3567 | 3640 | 3713 | 73 |
| 4 | 3786 | 3860 | 3933 | 4006 | 4079 | 4152 | 4225 | 4298 | 4371 | 4444 | 73 |
| 5 | 4517 | 4590 | 4663 | 4736 | 4809 | 4882 | 4955 | 5028 | 5100 | 5173 | 73 |
| 6 | 5246 | 5319 | 5392 | 5465 | 5538 | 5610 | 5683 | 5756 | 5829 | 5902 | 73 |
| 7 | 5974 | 6047 | 6120 | 6193 | 6265 | 6338 | 6411 | 6483 | 6556 | 6629 | 73 |
| 8 | 6701 | 6774 | 6846 | 6919 | 6992 | 7064 | 7137 | 7209 | 7282 | 7354 | 73 |
| 9 | 7427 | 7499 | 7572 | 7644 | 7717 | 7789 | 7862 | 7934 | 8006 | 8079 | 72 |
| 600 | 778151 | 778224 | 778296 | 778368 | 778441 | 778513 | 778585 | 778658 | 778730 | 778802 | 72 |
| 1 | 8874 | 8947 | 9019 | 9091 | 9163 | 9236 | 9308 | 9380 | 9452 | 9524 | 72 |
| 2 | 9596 | 9669 | 9741 | 9813 | 9885 | 9957 | 780029 | 780101 | 780173 | 780245 | 72 |
| 3 | 780317 | 780389 | 780461 | 780533 | 780605 | 780677 | 0749 | 0821 | 0893 | 0965 | 72 |
| 4 | 1037 | 1109 | 1181 | 1253 | 1324 | 1396 | 1468 | 1540 | 1612 | 1684 | 72 |
| 5 | 1755 | 1827 | 1899 | 1971 | 2042 | 2114 | 2186 | 2258 | 2329 | 2401 | 72 |
| 6 | 2473 | 2544 | 2616 | 2688 | 2759 | 2831 | 2902 | 2974 | 3046 | 3117 | 72 |
| 7 | 3189 | 3260 | 3332 | 3403 | 3475 | 3546 | 3618 | 3689 | 3761 | 3832 | 71 |
| 8 | 3904 | 3975 | 4046 | 4118 | 4189 | 4261 | 4332 | 4403 | 4475 | 4546 | 71 |
| 9 | 4617 | 4689 | 4760 | 4831 | 4902 | 4974 | 5045 | 5116 | 5187 | 5259 | 71 |
| 610 | 785330 | 785401 | 785472 | 785542 | 785615 | 785686 | 785757 | 785828 | 785899 | 785970 | 71 |
| 1 | 6041 | 6112 | 6183 | 6254 | 6325 | 6396 | 6467 | 6538 | 6609 | 6680 | 71 |
| 2 | 6751 | 6822 | 6893 | 6964 | 7035 | 7106 | 7177 | 7248 | 7319 | 7390 | 71 |
| 3 | 7460 | 7531 | 7602 | 7673 | 7744 | 7815 | 7885 | 7956 | 8027 | 8098 | 71 |
| 4 | 8168 | 8239 | 8310 | 8381 | 8451 | 8522 | 8593 | 8663 | 8734 | 8804 | 71 |
| 5 | 8875 | 8946 | 9016 | 9087 | 9157 | 9228 | 9299 | 9369 | 9440 | 9510 | 71 |
| 6 | 9581 | 9651 | 9722 | 9792 | 9863 | 9933 | 790004 | 790074 | 790144 | 790215 | 70 |
| 7 | 790285 | 790356 | 790426 | 790496 | 790567 | 790637 | 0707 | 0778 | 0848 | 0918 | 70 |
| 8 | 0988 | 1059 | 1129 | 1199 | 1269 | 1340 | 1410 | 1480 | 1550 | 1620 | 70 |
| 9 | 1691 | 1761 | 1831 | 1901 | 1971 | 2041 | 2111 | 2181 | 2252 | 2322 | 70 |
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| 2 | 3790 | 3860 | 3930 | 4000 | 4070 | 4139 | 4209 | 4279 | 4349 | 4418 | 70 |
| 3 | 4488 | 4558 | 4627 | 4697 | 4767 | 4836 | 4906 | 4976 | 5045 | 4115 | 70 |
| 4 | 5185 | 5254 | 5324 | 5393 | 5463 | 5532 | 5602 | 5672 | 5741 | 5811 | 70 |
| 5 | 5880 | 5949 | 6019 | 6088 | 6158 | 6227 | 6297 | 6366 | 6436 | 6505 | 69 |
| 6 | 6574 | 6644 | 6713 | 6782 | 6852 | 6921 | 6990 | 7060 | 7129 | 7198 | 69 |
| 7 | 7268 | 7337 | 7406 | 7475 | 7545 | 7614 | 7683 | 7752 | 7821 | 7890 | 69 |
| 8 | 7960 | 8029 | 8098 | 8167 | 8236 | 8305 | 8374 | 8443 | 8513 | 8582 | 69 |
| 9 | 8651 | 8720 | 8789 | 8858 | 8927 | 8996 | 9065 | 9134 | 9203 | 9272 | 69 |
| 630 | 799341 | 799409 | 799478 | 799547 | 799616 | 799685 | 799754 | 799823 | 799892 | 799961 | 69 |
| 1 | 800029 | 800098 | 800167 | 800236 | 800305 | 800373 | 800442 | 800511 | 800580 | 800648 | 69 |
| 2 | 0717 | 0786 | 0854 | 0923 | 0992 | 1061 | 1129 | 1198 | 1266 | 1335 | 69 |
| 3 | 1404 | 1472 | 1541 | 1609 | 1678 | 1747 | 1815 | 1884 | 1952 | 2021 | 69 |
| 4 | 2089 | 2158 | 2226 | 2295 | 2363 | 2432 | 2500 | 2568 | 2637 | 2705 | 68 |
| 5 | 2774 | 2842 | 2910 | 2979 | 3047 | 3116 | 3184 | 3252 | 3321 | 3389 | 68 |
| 6 | 3457 | 3525 | 3594 | 3662 | 3730 | 3798 | 3867 | 3935 | 4003 | 4071 | 68 |
| 7 | 4139 | 4208 | 4276 | 4344 | 4412 | 4480 | 4548 | 4616 | 4685 | 4753 | 68 |
| 8 | 4821 | 4889 | 4957 | 5025 | 5093 | 5161 | 5229 | 5297 | 5365 | 5433 | 68 |
| 9 | 5501 | 5569 | 5637 | 5705 | 5773 | 5841 | 5908 | 5976 | 6044 | 6112 | 68 |
| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Dif. |

| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Diff. |
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| 1 | 6858 | 6926 | 6994 | 7061 | 7129 | 7197 | 7264 | 7332 | 7400 | 7467 | 68 |
| 2 | 7535 | 7603 | 7670 | 7738 | 7806 | 7873 | 7941 | 8008 | 8076 | 8143 | 68 |
| 3 | 8211 | 8279 | 8346 | 8414 | 8481 | 8549 | 8616 | 8684 | 8751 | 8818 | 67 |
| 4 | 8886 | 8953 | 9021 | 9088 | 9156 | 9223 | 9290 | 9358 | 9425 | 9492 | 67 |
| 5 | 9560 | 9627 | 9694 | 9762 | 9829 | 9896 | 9964 | 810031 | 810098 | 810165 | 67 |
| 6 | 810233 | 810300 | 810367 | 810434 | 810501 | 810569 | 810636 | 0703 | 0770 | 0837 | 67 |
| 7 | 0904 | 0971 | 1039 | 1106 | 1173 | 1240 | 1307 | 1374 | 1441 | 1508 | 67 |
| 8 | 1575 | 1642 | 1709 | 1776 | 1843 | 1910 | 1977 | 2044 | 2111 | 2178 | 67 |
| 9 | 2245 | 2312 | 2379 | 2445 | 2512 | 2579 | 2646 | 2713 | 2780 | 2847 | 67 |
| 650 | 812913 | 812980 | 813047 | 813114 | 813181 | 813247 | 813314 | 813381 | 813448 | 813514 | 67 |
| 1 | 3581 | 3648 | 3714 | 3781 | 3848 | 3914 | 3981 | 4048 | 4114 | 4181 | 67 |
| 2 | 4248 | 4314 | 4381 | 4447 | 4514 | 4581 | 4647 | 4714 | 4780 | 4847 | 67 |
| 3 | 4913 | 4980 | 5046 | 5113 | 5179 | 5246 | 5312 | 5378 | 5445 | 5511 | 66 |
| 4 | 5578 | 5644 | 5711 | 5777 | 5843 | 5910 | 5976 | 6042 | 6109 | 6175 | 66 |
| 5 | 6241 | 6308 | 6374 | 6440 | 6506 | 6573 | 6639 | 6705 | 6771 | 6838 | 66 |
| 6 | 6904 | 6970 | 7036 | 7102 | 7169 | 7235 | 7301 | 7367 | 7433 | 7499 | 66 |
| 7 | 7565 | 7631 | 7698 | 7764 | 7830 | 7896 | 7962 | 8028 | 8094 | 8160 | 66 |
| 8 | 8226 | 8292 | 8358 | 8424 | 8490 | 8556 | 8622 | 8688 | 8754 | 8820 | 66 |
| 9 | 8885 | 8951 | 9017 | 9083 | 9149 | 9215 | 9281 | 9346 | 9412 | 9478 | 66 |
| 660 | 819544 | 819610 | 819676 | 819741 | 819807 | 819873 | 819939 | 820004 | 820070 | 820136 | 66 |
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| 3 | 1514 | 1579 | 1645 | 1710 | 1775 | 1841 | 1906 | 1972 | 2037 | 2103 | 65 |
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| 7 | 4126 | 4191 | 4256 | 4321 | 4386 | 4451 | 4516 | 4581 | 4646 | 4711 | 65 |
| 8 | 4776 | 4841 | 4906 | 4971 | 5036 | 5101 | 5166 | 5231 | 5296 | 5361 | 65 |
| 9 | 5426 | 5491 | 5556 | 5621 | 5686 | 5751 | 5815 | 5880 | 5945 | 6010 | 65 |
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| 2 | 7369 | 7434 | 7499 | 7563 | 7628 | 7692 | 7757 | 7821 | 7886 | 7951 | 65 |
| 3 | 8015 | 8080 | 8144 | 8209 | 8273 | 8338 | 8402 | 8467 | 8531 | 8595 | 64 |
| 4 | 8660 | 8724 | 8789 | 8853 | 8918 | 8982 | 9046 | 9111 | 9175 | 9239 | 64 |
| 5 | 9304 | 9368 | 9432 | 9497 | 9561 | 9625 | 9690 | 9754 | 9818 | 9882 | 64 |
| 6 | 9947 | 830011 | 830075 | 830139 | 830204 | 830268 | 830332 | 830396 | 830460 | 830525 | 64 |
| 7 | 830589 | 0653 | 0717 | 0781 | 0845 | 0909 | 0973 | 1037 | 1102 | 1166 | 64 |
| 8 | 1230 | 1294 | 1358 | 1422 | 1486 | 1550 | 1614 | 1678 | 1742 | 1806 | 64 |
| 9 | 1870 | 1934 | 1998 | 2062 | 2126 | 2189 | 2253 | 2317 | 2381 | 2445 | 64 |
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| 2 | 3784 | 3848 | 3912 | 3975 | 4039 | 4103 | 4166 | 4230 | 4294 | 4357 | 64 |
| 3 | 4421 | 4484 | 4548 | 4611 | 4675 | 4739 | 4802 | 4866 | 4929 | 4993 | 64 |
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| 6 | 6324 | 6387 | 6451 | 6514 | 6577 | 6641 | 6704 | 6767 | 6830 | 6894 | 63 |
| 7 | 6957 | 7020 | 7083 | 7146 | 7210 | 7273 | 7336 | 7399 | 7462 | 7525 | 63 |
| 8 | 7588 | 7652 | 7715 | 7778 | 7841 | 7904 | 7967 | 8030 | 8093 | 8156 | 63 |
| 9 | 8219 | 8282 | 8345 | 8408 | 8471 | 8534 | 8597 | 8660 | 8723 | 8786 | 63 |
| 690 | 838849 | 838912 | 838975 | 839038 | 839101 | 839164 | 839227 | 839289 | 839352 | 839415 | 63 |
| 1 | 9478 | 9541 | 9604 | 9667 | 9729 | 9792 | 9855 | 9918 | 9981 | 840043 | 63 |
| 2 | 840106 | 840169 | 840232 | 840294 | 840357 | 840420 | 840482 | 840545 | 840608 | 0671 | 63 |
| 3 | 0733 | 0796 | 0859 | 0921 | 0984 | 1046 | 1109 | 1172 | 1234 | 1297 | 63 |
| 4 | 1359 | 1422 | 1485 | 1547 | 1610 | 1672 | 1735 | 1797 | 1860 | 1922 | 63 |
| 5 | 1985 | 2047 | 2110 | 2172 | 2235 | 2297 | 2360 | 2422 | 2484 | 2547 | 62 |
| 6 | 2609 | 2672 | 2734 | 2796 | 2859 | 2921 | 2983 | 3046 | 3108 | 3170 | 62 |
| 7 | 3233 | 3295 | 3357 | 3420 | 3482 | 3544 | 3606 | 3669 | 3731 | 3793 | 62 |
| 8 | 3855 | 3918 | 3980 | 4042 | 4104 | 4166 | 4229 | 4291 | 4353 | 4415 | 62 |
| 9 | 4477 | 4539 | 4601 | 4664 | 4726 | 4788 | 4850 | 4912 | 4974 | 5036 | 62 |
| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Diff. |

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| 4 | 7573 | 7634 | 7696 | 7758 | 7819 | 7881 | 7943 | 8004 | 8066 | 8128 | 62 |
| 5 | 8189 | 8251 | 8312 | 8374 | 8435 | 8497 | 8559 | 8620 | 8682 | 8743 | 62 |
| 6 | 8805 | 8866 | 8928 | 8989 | 9051 | 9112 | 9174 | 9235 | 9297 | 9358 | 61 |
| 7 | 9419 | 9481 | 9542 | 9604 | 9665 | 9726 | 9788 | 9849 | 9911 | 9972 | 61 |
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| 9 | 0646 | 0707 | 0769 | 0830 | 0891 | 0952 | 1014 | 1075 | 1136 | 1197 | 61 |
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| 9 | 6729 | 6789 | 6850 | 6910 | 6970 | 7031 | 7091 | 7152 | 7212 | 7272 | 60 |
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| 7 | 1534 | 1594 | 1654 | 1714 | 1773 | 1833 | 1893 | 1952 | 2012 | 2072 | 60 |
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| 6 | 6878 | 6937 | 6996 | 7055 | 7114 | 7173 | 7232 | 7291 | 7350 | 7409 | 59 |
| 7 | 7467 | 7526 | 7585 | 7644 | 7703 | 7762 | 7821 | 7880 | 7939 | 7998 | 59 |
| 8 | 8056 | 8115 | 8174 | 8233 | 8292 | 8350 | 8409 | 8468 | 8527 | 8586 | 59 |
| 9 | 8644 | 8703 | 8762 | 8821 | 8879 | 8938 | 8997 | 9056 | 9114 | 9173 | 59 |
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| 1 | 9818 | 9877 | 9935 | 9994 | 870053 | 970111 | 870170 | 870228 | 870287 | 870345 | 59 |
| 2 | 870404 | 870462 | 870521 | 870579 | 0638 | 0696 | 0755 | 0813 | 0872 | 0930 | 58 |
| 3 | 0989 | 1047 | 1106 | 1164 | 1223 | 1281 | 1339 | 1398 | 1456 | 1515 | 58 |
| 4 | 1573 | 1631 | 1690 | 1748 | 1806 | 1865 | 1923 | 1981 | 2040 | 2098 | 58 |
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| 6 | 2739 | 2797 | 2855 | 2913 | 2972 | 3030 | 3088 | 3146 | 3204 | 3262 | 58 |
| 7 | 3321 | 3379 | 3437 | 3495 | 3553 | 3611 | 3669 | 3727 | 3785 | 3844 | 58 |
| 8 | 3902 | 3960 | 4018 | 4076 | 4134 | 4192 | 4250 | 4308 | 4366 | 4424 | 58 |
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| 3 | 6795 | 6853 | 6910 | 6968 | 7026 | 7083 | 7141 | 7199 | 7256 | 7314 | 58 |
| 4 | 7371 | 7429 | 7487 | 7544 | 7602 | 7659 | 7717 | 7774 | 7832 | 7889 | 58 |
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| 6 | 8522 | 8579 | 8637 | 8694 | 8752 | 8809 | 8866 | 8924 | 8981 | 9039 | 57 |
| 7 | 9096 | 9153 | 9211 | 9268 | 9325 | 9383 | 9440 | 9497 | 9555 | 9612 | 57 |
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| 4 | 3093 | 3150 | 3207 | 3264 | 3321 | 3377 | 3434 | 3491 | 3548 | 3605 | 57 |
| 5 | 3661 | 3718 | 3775 | 3832 | 3888 | 3945 | 4002 | 4059 | 4115 | 4172 | 57 |
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| 5 | 9302 | 9358 | 9414 | 9470 | 9526 | 9582 | 9638 | 9694 | 9750 | 9806 | 56 |
| 6 | 9862 | 9918 | 9974 | 890030 | 890086 | 890141 | 890197 | 890253 | 890309 | 890365 | 56 |
| 7 | 890421 | 890477 | 890533 | 0589 | 9645 | 0700 | 0756 | 0812 | 0868 | 0924 | 56 |
| 8 | 0980 | 1035 | 1091 | 1147 | 1203 | 1259 | 1314 | 1370 | 1426 | 1482 | 56 |
| 9 | 1537 | 1593 | 1649 | 1705 | 1760 | 1816 | 1872 | 1928 | 1983 | 2039 | 56 |
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| 4 | 4316 | 4371 | 4427 | 4482 | 4538 | 4593 | 4648 | 4704 | 4759 | 4814 | 55 |
| 5 | 4870 | 4925 | 4980 | 5036 | 5091 | 5146 | 5201 | 5257 | 5312 | 5367 | 55 |
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| 7 | 5975 | 6030 | 6085 | 6140 | 6195 | 6251 | 6306 | 6361 | 6416 | 6471 | 55 |
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| 3 | 9273 | 9328 | 9383 | 9437 | 9492 | 9547 | 9602 | 9656 | 9711 | 9766 | 55 |
| 4 | 9821 | 9875 | 9930 | 9985 | 900039 | 900094 | 900149 | 900203 | 900258 | 900312 | 55 |
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| 2 | 4174 | 4229 | 4283 | 4337 | 4391 | 4445 | 4499 | 4553 | 4607 | 4661 | 54 |
| 3 | 4716 | 4770 | 4824 | 4878 | 4932 | 4986 | 5040 | 5094 | 5148 | 5202 | 54 |
| 4 | 5256 | 5310 | 5364 | 5418 | 5472 | 5526 | 5580 | 5634 | 5688 | 5742 | 54 |
| 5 | 5796 | 5850 | 5904 | 5958 | 6012 | 6066 | 6119 | 6173 | 6227 | 6281 | 54 |
| 6 | 6335 | 6389 | 6443 | 6497 | 6551 | 6604 | 6658 | 6712 | 6766 | 6820 | 54 |
| 7 | 6874 | 6927 | 6981 | 7035 | 7089 | 7143 | 7196 | 7250 | 7304 | 7358 | 54 |
| 8 | 7411 | 7465 | 7519 | 7573 | 7626 | 7680 | 7734 | 7787 | 7841 | 7895 | 54 |
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| 5 | 1158 | 1211 | 1264 | 1317 | 1371 | 1424 | 1477 | 1530 | 1584 | 1637 | 53 |
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| 4 | 5927 | 5980 | 6033 | 6085 | 6138 | 6191 | 6243 | 6296 | 6349 | 6401 | 53 |
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| 3 | 0645 | 0697 | 0749 | 0801 | 0853 | 0906 | 0958 | 1010 | 1062 | 1114 | 52 |
| 4 | 1166 | 1218 | 1270 | 1322 | 1374 | 1426 | 1478 | 1530 | 1582 | 1634 | 52 |
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| 6 | 2206 | 2258 | 2310 | 2362 | 2414 | 2466 | 2518 | 2570 | 2622 | 2674 | 52 |
| 7 | 2725 | 2777 | 2829 | 2881 | 2933 | 2985 | 3037 | 3089 | 3140 | 3192 | 52 |
| 8 | 3244 | 3296 | 3348 | 3399 | 3451 | 3503 | 3555 | 3607 | 3658 | 3710 | 52 |
| 9 | 3762 | 3814 | 3865 | 3917 | 3969 | 4021 | 4072 | 4124 | 4176 | 4228 | 52 |
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| 1 | 5003 | 5054 | 5104 | 5154 | 5205 | 5255 | 5306 | 5356 | 5406 | 5457 | 50 |
| 2 | 5507 | 5558 | 5608 | 5658 | 5709 | 5759 | 5809 | 5860 | 5910 | 5960 | 50 |
| 3 | 6011 | 6061 | 6111 | 6162 | 6212 | 6262 | 6313 | 6363 | 6413 | 6463 | 50 |
| 4 | 6514 | 6564 | 6614 | 6665 | 6715 | 6765 | 6815 | 6865 | 6916 | 6966 | 50 |
| 5 | 7016 | 7066 | 7117 | 7167 | 7217 | 7267 | 7317 | 7367 | 7418 | 7468 | 50 |
| 6 | 7518 | 7568 | 7618 | 7668 | 7718 | 7769 | 7819 | 7869 | 7919 | 7969 | 50 |
| 7 | 8019 | 8069 | 8119 | 8169 | 8219 | 8269 | 8320 | 8370 | 8420 | 8470 | 50 |
| 8 | 8520 | 8570 | 8620 | 8670 | 8720 | 8770 | 8820 | 8870 | 8920 | 8970 | 50 |
| 9 | 9020 | 9070 | 9120 | 8170 | 9220 | 9270 | 9320 | 9369 | 9419 | 9469 | 50 |
| 870 | 939519 | 939569 | 930619 | 939669 | 939719 | 939769 | 939819 | 939869 | 939918 | 939968 | 50 |
| 1 | 940018 | 940068 | 940118 | 940168 | 940218 | 940267 | 940317 | 940367 | 940417 | 940467 | 50 |
| 2 | 0516 | 0566 | 0616 | 0666 | 0716 | 0765 | 0815 | 0865 | 0915 | 0964 | 50 |
| 3 | 1014 | 1064 | 1114 | 1163 | 1213 | 1263 | 1313 | 1362 | 1412 | 1462 | 50 |
| 4 | 1511 | 1561 | 1611 | 1660 | 1710 | 1760 | 1809 | 1859 | 1909 | 1958 | 50 |
| 5 | 2008 | 2058 | 2107 | 2157 | 2207 | 2256 | 2306 | 2355 | 2405 | 2455 | 50 |
| 6 | 2504 | 2554 | 2603 | 2653 | 2702 | 2752 | 2801 | 2851 | 2901 | 2950 | 50 |
| 7 | 3000 | 3049 | 3099 | 3148 | 3198 | 3247 | 3297 | 3346 | 3396 | 3445 | 49 |
| 8 | 3495 | 3544 | 3593 | 3643 | 3692 | 3742 | 3791 | 3841 | 3890 | 3939 | 49 |
| 9 | 3989 | 4038 | 4088 | 4137 | 4186 | 4236 | 4285 | 4335 | 4384 | 4433 | 49 |
| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Dif. |

| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Dif. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 880 | 944483 | 944532 | 944581 | 944631 | 944680 | 944729 | 944779 | 944828 | 944877 | 944927 | 49 |
| 1 | 4976 | 5025 | 5074 | 5124 | 5173 | 5222 | 5272 | 5321 | 5370 | 5419 | 49 |
| 2 | 5469 | 5518 | 5567 | 5616 | 5665 | 5715 | 5764 | 5813 | 5862 | 5912 | 49 |
| 3 | 5961 | 6010 | 6059 | 6108 | 6157 | 6207 | 6256 | 6305 | 6354 | 6403 | 49 |
| 4 | 6452 | 6501 | 6551 | 6600 | 6649 | 6698 | 6747 | 6796 | 6845 | 6894 | 49 |
| 5 | 6943 | 6992 | 7041 | 7090 | 7140 | 7189 | 7238 | 7287 | 7336 | 7385 | 49 |
| 6 | 7434 | 7483 | 7532 | 7581 | 7630 | 7679 | 7728 | 7777 | 7826 | 7875 | 49 |
| 7 | 7924 | 7973 | 8022 | 8070 | 8119 | 8168 | 8217 | 8266 | 8315 | 8364 | 49 |
| 8 | 8413 | 8462 | 8511 | 8560 | 8609 | 8657 | 8706 | 8755 | 8804 | 8853 | 49 |
| 9 | 8902 | 8951 | 8999 | 9048 | 9097 | 9146 | 9195 | 9244 | 9292 | 9341 | 49 |
| 890 | 949390 | 949439 | 949488 | 949536 | 949585 | 949634 | 949683 | 949731 | 949780 | 949829 | 49 |
| 1 | 9878 | 9926 | 9975 | 950024 | 950073 | 950121 | 950170 | 950219 | 950267 | 950316 | 49 |
| 2 | 950365 | 950414 | 950462 | 0511 | 0560 | 0608 | 0657 | 0706 | 0754 | 0803 | 49 |
| 3 | 0851 | 0900 | 0949 | 0997 | 1046 | 1095 | 1143 | 1192 | 1240 | 1289 | 49 |
| 4 | 1338 | 1386 | 1435 | 1483 | 1532 | 1580 | 1629 | 1677 | 1726 | 1775 | 49 |
| 5 | 1823 | 1872 | 1920 | 1969 | 2017 | 2066 | 2114 | 2163 | 2211 | 2260 | 48 |
| 6 | 2308 | 2356 | 2405 | 2453 | 2502 | 2550 | 2599 | 2647 | 2696 | 2744 | 48 |
| 7 | 2792 | 2841 | 2889 | 2938 | 2986 | 3034 | 3083 | 3131 | 3180 | 3228 | 48 |
| 8 | 3276 | 3325 | 3373 | 3421 | 3470 | 3518 | 3566 | 3615 | 3663 | 3711 | 48 |
| 9 | 3760 | 3808 | 3856 | 3905 | 3953 | 4001 | 4049 | 4098 | 4146 | 4194 | 48 |
| 900 | 954243 | 954291 | 954339 | 954387 | 954435 | 954484 | 954532 | 954580 | 954628 | 954677 | 48 |
| 1 | 4725 | 4773 | 4821 | 4869 | 4918 | 4966 | 5014 | 5062 | 5110 | 5158 | 48 |
| 2 | 5207 | 5255 | 5303 | 5351 | 5399 | 5447 | 5495 | 5543 | 5592 | 5640 | 48 |
| 3 | 5688 | 5736 | 5784 | 5832 | 5880 | 5928 | 5976 | 6024 | 6072 | 6120 | 48 |
| 4 | 6168 | 6216 | 6265 | 6313 | 6361 | 6409 | 6457 | 6505 | 6553 | 6601 | 48 |
| 5 | 6649 | 6697 | 6745 | 6793 | 6840 | 6888 | 6936 | 6984 | 7032 | 7080 | 48 |
| 6 | 7128 | 7176 | 7224 | 7272 | 7320 | 7368 | 7416 | 7464 | 7512 | 7559 | 48 |
| 7 | 7607 | 7655 | 7703 | 7751 | 7799 | 7847 | 7894 | 7942 | 7990 | 8038 | 48 |
| 8 | 8086 | 8134 | 8181 | 8229 | 8277 | 8325 | 8373 | 8421 | 8468 | 8516 | 48 |
| 9 | 8564 | 8612 | 8659 | 8707 | 8755 | 8803 | 8850 | 8898 | 8946 | 8994 | 48 |
| 910 | 959041 | 959089 | 959137 | 959185 | 959232 | 959280 | 959328 | 959375 | 959423 | 959471 | 48 |
| 1 | 9518 | 9566 | 9614 | 9661 | 9709 | 9757 | 9804 | 9852 | 9900 | 9947 | 48 |
| 2 | 9995 | 960042 | 960090 | 960138 | 960185 | 960233 | 960281 | 960328 | 960376 | 960423 | 48 |
| 3 | 960471 | 0518 | 0566 | 0613 | 0661 | 0709 | 0756 | 0804 | 0851 | 0899 | 48 |
| 4 | 0946 | 0994 | 1041 | 1089 | 1136 | 1184 | 1231 | 1279 | 1326 | 1374 | 48 |
| 5 | 1421 | 1469 | 1516 | 1563 | 1611 | 1658 | 1706 | 1753 | 1801 | 1848 | 47 |
| 6 | 1895 | 1943 | 1990 | 2038 | 2085 | 2132 | 2180 | 2227 | 2275 | 2322 | 47 |
| 7 | 2369 | 2417 | 2464 | 2511 | 2559 | 2606 | 2653 | 2701 | 2748 | 2795 | 47 |
| 8 | 2843 | 2890 | 2937 | 2985 | 3032 | 3079 | 3126 | 3174 | 3221 | 3268 | 47 |
| 9 | 3316 | 3363 | 3410 | 3457 | 3504 | 3552 | 3599 | 3646 | 3693 | 3741 | 47 |
| 920 | 963788 | 963835 | 963882 | 963929 | 963977 | 964024 | 964071 | 964118 | 964165 | 964212 | 47 |
| 1 | 4260 | 4307 | 4354 | 4401 | 4448 | 4495 | 4542 | 4590 | 4637 | 4684 | 47 |
| 2 | 4731 | 4778 | 4825 | 4872 | 4919 | 4966 | 5013 | 5061 | 5108 | 5155 | 47 |
| 3 | 5202 | 5249 | 5296 | 5343 | 5390 | 5437 | 5484 | 5531 | 5578 | 5625 | 47 |
| 4 | 5672 | 5719 | 5766 | 5813 | 5860 | 5907 | 5954 | 6001 | 6048 | 6095 | 47 |
| 5 | 6142 | 6189 | 6236 | 6283 | 6329 | 6376 | 6423 | 6470 | 6517 | 6564 | 47 |
| 6 | 6611 | 6658 | 6705 | 6752 | 6799 | 6845 | 6892 | 6939 | 6986 | 7033 | 47 |
| 7 | 7080 | 7127 | 7173 | 7220 | 7267 | 7314 | 7361 | 7408 | 7454 | 7501 | 47 |
| 8 | 7548 | 7595 | 7642 | 7688 | 7735 | 7782 | 7829 | 7875 | 7922 | 7969 | 47 |
| 9 | 8016 | 8062 | 8109 | 8156 | 8203 | 8249 | 8296 | 8343 | 8390 | 8436 | 47 |
| 930 | 968483 | 968530 | 968576 | 968623 | 968670 | 968716 | 968763 | 968810 | 968856 | 968903 | 47 |
| 1 | 8950 | 8996 | 9043 | 9090 | 9136 | 9183 | 9229 | 9276 | 9323 | 9369 | 47 |
| 2 | 9416 | 9463 | 9509 | 9556 | 9602 | 9649 | 9695 | 9742 | 9789 | 9835 | 47 |
| 3 | 9882 | 9928 | 9975 | 970021 | 970068 | 970114 | 970161 | 970207 | 970254 | 970300 | 47 |
| 4 | 970347 | 970393 | 970440 | 0486 | 0533 | 0579 | 0626 | 0672 | 0719 | 0765 | 46 |
| 5 | 0812 | 0858 | 0904 | 0951 | 0997 | 1044 | 1090 | 1137 | 1183 | 1229 | 46 |
| 6 | 1276 | 1322 | 1369 | 1415 | 1461 | 1508 | 1554 | 1601 | 1647 | 1693 | 46 |
| 7 | 1740 | 1786 | 1832 | 1879 | 1925 | 1971 | 2018 | 2064 | 2110 | 2157 | 46 |
| 8 | 2203 | 2249 | 2295 | 2342 | 2388 | 2434 | 2481 | 2527 | 2573 | 2619 | 46 |
| 9 | 2666 | 2712 | 2758 | 2801 | 2851 | 28.7 | 2943 | 2989 | 3035 | 3082 | 46 |
| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Dif. |

| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 940 | 973128 | 973174 | 973220 | 973266 | 973313 | 973359 | 973405 | 973451 | 973497 | 973543 | 46 |
| 1 | 3590 | 3636 | 3682 | 3728 | 3774 | 3820 | 3866 | 3913 | 3959 | 4005 | 46 |
| 2 | 4051 | 4097 | 4143 | 4189 | 4235 | 4281 | 4327 | 4374 | 4420 | 4466 | 46 |
| 3 | 4512 | 4558 | 4604 | 4650 | 4696 | 4742 | 4788 | 4834 | 4880 | 4926 | 46 |
| 4 | 4972 | 5018 | 5064 | 5110 | 5156 | 5202 | 5248 | 5294 | 5340 | 5386 | 46 |
| 5 | 5432 | 5478 | 5524 | 5570 | 5616 | 5662 | 5707 | 5753 | 5799 | 5845 | 46 |
| 6 | 5891 | 5937 | 5983 | 6029 | 6075 | 6121 | 6167 | 6212 | 6258 | 6304 | 46 |
| 7 | 6350 | 6396 | 6442 | 6488 | 6533 | 6579 | 6625 | 6671 | 6717 | 6763 | 46 |
| 8 | 6808 | 6854 | 6900 | 6946 | 6992 | 7037 | 7083 | 7129 | 7175 | 7220 | 46 |
| 9 | 7266 | 7312 | 7358 | 7403 | 7449 | 7495 | 7541 | 7586 | 7632 | 7678 | 46 |
| 950 | 977724 | 977769 | 977815 | 977861 | 977906 | 977952 | 977998 | 978043 | 978089 | 978135 | 46 |
| 1 | 8181 | 8226 | 8272 | 8317 | 8363 | 8409 | 8454 | 8500 | 8546 | 8591 | 46 |
| 2 | 8637 | 8683 | 8728 | 8774 | 8819 | 8865 | 8911 | 8956 | 9002 | 9047 | 46 |
| 3 | 9093 | 9138 | 9184 | 9230 | 9275 | 9321 | 9366 | 9412 | 9457 | 9503 | 46 |
| 4 | 9548 | 9594 | 9639 | 9685 | 9730 | 9776 | 9821 | 9867 | 9912 | 9958 | 46 |
| 5 | 980003 | 980049 | 980094 | 980140 | 980185 | 980231 | 980276 | 980322 | 980367 | 980412 | 45 |
| 6 | 0458 | 0503 | 0549 | 0594 | 0640 | 0685 | 0730 | 0776 | 0821 | 0867 | 45 |
| 7 | 0912 | 0957 | 1003 | 1048 | 1093 | 1139 | 1184 | 1229 | 1275 | 1320 | 45 |
| 8 | 1366 | 1411 | 1456 | 1501 | 1547 | 1592 | 1637 | 1683 | 1728 | 1773 | 45 |
| 9 | 1819 | 1864 | 1909 | 1954 | 2000 | 2045 | 2090 | 2135 | 2181 | 2226 | 45 |
| 960 | 982271 | 982316 | 982362 | 982407 | 982452 | 982497 | 982543 | 982588 | 982633 | 982678 | 45 |
| 1 | 2723 | 2769 | 2814 | 2859 | 2904 | 2949 | 2994 | 3040 | 3085 | 3130 | 45 |
| 2 | 3175 | 3220 | 3265 | 3310 | 3356 | 3401 | 3446 | 3491 | 3536 | 3581 | 45 |
| 3 | 3626 | 3671 | 3716 | 3762 | 3807 | 3852 | 3897 | 3942 | 3987 | 4032 | 45 |
| 4 | 4077 | 4122 | 4167 | 4212 | 4257 | 4302 | 4347 | 4392 | 4437 | 4482 | 45 |
| 5 | 4527 | 4572 | 4617 | 4662 | 4707 | 4752 | 4797 | 4842 | 4887 | 4932 | 45 |
| 6 | 4977 | 5022 | 5067 | 5112 | 5157 | 5202 | 5247 | 5292 | 5337 | 5382 | 45 |
| 7 | 5426 | 5471 | 5516 | 5561 | 5606 | 5651 | 5696 | 5741 | 5786 | 5830 | 45 |
| 8 | 5875 | 5920 | 5965 | 6010 | 6055 | 6100 | 6144 | 6189 | 6234 | 6279 | 45 |
| 9 | 6324 | 6369 | 6413 | 6458 | 6503 | 6548 | 6593 | 6637 | 6682 | 6727 | 45 |
| 970 | 986772 | 986817 | 986861 | 986906 | 986951 | 986996 | 987040 | 987085 | 987130 | 987175 | 45 |
| 1 | 7219 | 7264 | 7309 | 7353 | 7398 | 7443 | 7488 | 7532 | 7577 | 7622 | 45 |
| 2 | 7666 | 7711 | 7756 | 7800 | 7845 | 7890 | 7934 | 7979 | 8024 | 8068 | 45 |
| 3 | 8113 | 8157 | 8202 | 8247 | 8291 | 8336 | 8381 | 8425 | 8470 | 8514 | 45 |
| 4 | 8559 | 8604 | 8648 | 8693 | 8737 | 8782 | 8826 | 8871 | 8916 | 8960 | 45 |
| 5 | 9005 | 9049 | 9094 | 9138 | 9183 | 9227 | 9272 | 9316 | 9361 | 9405 | 45 |
| 6 | 9450 | 9494 | 9539 | 9583 | 9628 | 9672 | 9717 | 9761 | 9806 | 9850 | 44 |
| 7 | 9895 | 9939 | 9983 | 990028 | 990072 | 990117 | 990161 | 990206 | 990250 | 990294 | 44 |
| 8 | 990339 | 990383 | 990428 | 0472 | 0516 | 0561 | 0605 | 0650 | 0694 | 0738 | 44 |
| 9 | 0783 | 0827 | 0871 | 0916 | 0960 | 1004 | 1049 | 1093 | 1137 | 1182 | 44 |
| 980 | 991226 | 991270 | 991315 | 991359 | 991403 | 991448 | 991492 | 991536 | 991580 | 991625 | 44 |
| 1 | 1669 | 1713 | 1758 | 1802 | 1846 | 1890 | 1935 | 1979 | 2023 | 2067 | 44 |
| 2 | 2111 | 2156 | 2200 | 2244 | 2288 | 2333 | 2377 | 2421 | 2465 | 2509 | 44 |
| 3 | 2554 | 2598 | 2642 | 2686 | 2730 | 2774 | 2819 | 2863 | 2907 | 2951 | 44 |
| 4 | 2995 | 3039 | 3083 | 3127 | 3172 | 3216 | 3260 | 3304 | 3348 | 3392 | 44 |
| 5 | 3436 | 3480 | 3524 | 3568 | 3613 | 3657 | 3701 | 3745 | 3789 | 3833 | 44 |
| 6 | 3877 | 3921 | 3965 | 4009 | 4053 | 4097 | 4141 | 4185 | 4229 | 4273 | 44 |
| 7 | 4317 | 4361 | 4405 | 4449 | 4493 | 4537 | 4581 | 4625 | 4669 | 4713 | 44 |
| 8 | 4757 | 4801 | 4845 | 4889 | 4933 | 4977 | 5021 | 5065 | 5108 | 5152 | 44 |
| 9 | 5196 | 5240 | 5284 | 5328 | 5372 | 5416 | 5460 | 5504 | 5547 | 5591 | 44 |
| 990 | 995635 | 995679 | 995723 | 995767 | 995811 | 995854 | 995898 | 995942 | 995986 | 996030 | 44 |
| 1 | 6074 | 6117 | 6161 | 6205 | 6249 | 6293 | 6337 | 6380 | 6424 | 6468 | 44 |
| 2 | 6512 | 6555 | 6599 | 6643 | 6687 | 6731 | 6774 | 6818 | 6862 | 6906 | 44 |
| 3 | 6949 | 6993 | 7037 | 7080 | 7124 | 7168 | 7212 | 7255 | 7299 | 7343 | 44 |
| 4 | 7386 | 7430 | 7474 | 7517 | 7561 | 7605 | 7648 | 7692 | 7736 | 7779 | 44 |
| 5 | 7823 | 7867 | 7910 | 7954 | 7998 | 8041 | 8085 | 8129 | 8172 | 8216 | 44 |
| 6 | 8259 | 8303 | 8347 | 8390 | 8434 | 8477 | 8521 | 8564 | 8608 | 8652 | 44 |
| 7 | 8695 | 8739 | 8782 | 8826 | 8869 | 8913 | 8956 | 9000 | 9043 | 9087 | 44 |
| 8 | 9131 | 9174 | 9218 | 9261 | 9305 | 9348 | 9392 | 9435 | 9479 | 9522 | 44 |
| 9 | 9565 | 9609 | 9652 | 9696 | 9739 | 9783 | 9826 | 9870 | 9913 | 9957 | 43 |
| No. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Diff. |

# TABLE IV.

# LOGARITHMIC

## SINES AND TANGENTS,

FOR EVERY

## DEGREE AND MINUTE

OF

THE QUADRANT.

---

N. B. The minutes in the left-hand column of each page, increasing downwards, belong to the degrees at the top; and those increasing upwards, in the right-hand column, belong to the degrees below.

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 0·000000 | | 10·000000 | | 0·000000 | | Infinite. | 60 |
| 1 | 6·463726 | 501717 | 000000 | 00 | 6·463726 | 501717 | 13·536274 | 59 |
| 2 | 764756 | 293485 | 000000 | 00 | 764756 | 293483 | 235244 | 58 |
| 3 | 940847 | 208231 | 000000 | 00 | 940847 | 208231 | 059153 | 57 |
| 4 | 7·065786 | 161517 | 000000 | 00 | 7·065786 | 161517 | 12·934214 | 56 |
| 5 | 162696 | 131968 | 000000 | 00 | 162696 | 131969 | 837304 | 55 |
| 6 | 241877 | 111575 | 9·999999 | 01 | 241878 | 111578 | 758122 | 54 |
| 7 | 308824 | 96653 | 999999 | 01 | 308825 | 99653 | 691175 | 53 |
| 8 | 366816 | 85254 | 999999 | 01 | 366817 | 85254 | 633183 | 52 |
| 9 | 417968 | 76263 | 999999 | 01 | 417970 | 76263 | 582030 | 51 |
| 10 | 463725 | 68988 | 999998 | 01 | 463727 | 68988 | 536273 | 50 |
| 11 | 7·505118 | 62981 | 9·999998 | 01 | 7·505120 | 62981 | 12·494880 | 49 |
| 12 | 542906 | 57936 | 999997 | 01 | 542909 | 57933 | 457091 | 48 |
| 13 | 577668 | 53641 | 999997 | 01 | 577672 | 53642 | 422328 | 47 |
| 14 | 609853 | 49938 | 999996 | 01 | 609857 | 49939 | 390143 | 46 |
| 15 | 639816 | 46714 | 999996 | 01 | 639820 | 46715 | 360180 | 45 |
| 16 | 667845 | 43881 | 999995 | 01 | 667849 | 43882 | 332151 | 44 |
| 17 | 694173 | 41372 | 999995 | 01 | 694179 | 41373 | 305821 | 43 |
| 18 | 718997 | 39135 | 999994 | 01 | 719003 | 39136 | 280997 | 42 |
| 19 | 742477 | 37127 | 999993 | 01 | 742484 | 37128 | 257516 | 41 |
| 20 | 764754 | 35315 | 999993 | 01 | 764761 | 35136 | 235239 | 40 |
| 21 | 7·785943 | 33672 | 9·999992 | 01 | 7·785951 | 33673 | 12·214049 | 39 |
| 22 | 806146 | 32175 | 999991 | 01 | 806155 | 32176 | 193845 | 38 |
| 23 | 825451 | 30805 | 999990 | 01 | 825460 | 30806 | 174540 | 37 |
| 24 | 843934 | 29547 | 999989 | 02 | 843944 | 29549 | 156056 | 36 |
| 25 | 861662 | 28388 | 999988 | 02 | 861674 | 28390 | 138326 | 35 |
| 26 | 878695 | 27317 | 999988 | 02 | 878708 | 27318 | 121292 | 34 |
| 27 | 895085 | 26323 | 999987 | 02 | 895099 | 26325 | 104901 | 33 |
| 28 | 910879 | 25399 | 999986 | 02 | 910894 | 25401 | 089106 | 32 |
| 29 | 926119 | 24538 | 999985 | 02 | 926134 | 24540 | 073866 | 31 |
| 30 | 940842 | 23733 | 999983 | 02 | 940858 | 23735 | 059142 | 30 |
| 31 | 7·955082 | 22980 | 9·999982 | 02 | 7·955100 | 22981 | 12·044900 | 29 |
| 32 | 968870 | 22273 | 999981 | 02 | 968889 | 22275 | 031111 | 28 |
| 33 | 982233 | 21608 | 999980 | 02 | 982253 | 21610 | 017747 | 27 |
| 34 | 995198 | 20981 | 999979 | 02 | 995219 | 20983 | 004781 | 26 |
| 35 | 8·007787 | 20390 | 999977 | 02 | 8·007809 | 20392 | 11·992191 | 25 |
| 36 | 020021 | 19831 | 999976 | 02 | 020045 | 19833 | 979955 | 24 |
| 37 | 031919 | 19302 | 999975 | 02 | 031945 | 19305 | 968055 | 23 |
| 38 | 043501 | 18801 | 999973 | 02 | 043527 | 18803 | 956473 | 22 |
| 39 | 054781 | 18325 | 999972 | 02 | 054809 | 18327 | 945191 | 21 |
| 40 | 065776 | 17872 | 999971 | 02 | 065806 | 17874 | 934194 | 20 |
| 41 | 8·076500 | 17441 | 9·999969 | 02 | 8·076531 | 17444 | 11·923469 | 19 |
| 42 | 086965 | 17031 | 999968 | 02 | 086997 | 17034 | 913003 | 18 |
| 43 | 097183 | 16639 | 999966 | 02 | 097217 | 16642 | 902783 | 17 |
| 44 | 107167 | 16265 | 999964 | 03 | 107202 | 16268 | 892797 | 16 |
| 45 | 116926 | 15908 | 999963 | 03 | 116963 | 15910 | 883037 | 15 |
| 46 | 126471 | 15566 | 999961 | 03 | 126510 | 15568 | 873490 | 14 |
| 47 | 135810 | 15238 | 999959 | 03 | 135851 | 15241 | 864149 | 13 |
| 48 | 144953 | 14924 | 999958 | 03 | 144996 | 14927 | 855004 | 12 |
| 49 | 153907 | 14622 | 999956 | 03 | 153952 | 14627 | 846048 | 11 |
| 50 | 162681 | 14333 | 999954 | 03 | 162727 | 14336 | 837273 | 10 |
| 51 | 8·171280 | 14054 | 9·999952 | 03 | 8·171328 | 14057 | 11·828672 | 9 |
| 52 | 179713 | 13786 | 999950 | 03 | 179763 | 13790 | 820237 | 8 |
| 53 | 187985 | 13529 | 999948 | 03 | 188036 | 13532 | 811964 | 7 |
| 54 | 196102 | 13280 | 999946 | 03 | 196156 | 13284 | 803844 | 6 |
| 55 | 204070 | 13041 | 999944 | 03 | 204126 | 13044 | 795874 | 5 |
| 56 | 211895 | 12810 | 999942 | 04 | 211953 | 12814 | 788047 | 4 |
| 57 | 219581 | 12587 | 999940 | 04 | 219641 | 12590 | 780359 | 3 |
| 58 | 227134 | 12372 | 999938 | 04 | 227195 | 12376 | 772805 | 2 |
| 59 | 234557 | 12164 | 999936 | 04 | 234621 | 12168 | 765379 | 1 |
| 60 | 241855 | 11963 | 999934 | 04 | 241921 | 11967 | 758079 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 8·241855 | 11963 | 9·999934 | 04 | 8·241921 | 11967 | 11·758079 | 60 |
| 1 | 249033 | 11768 | 999932 | 04 | 249102 | 11772 | 750898 | 59 |
| 2 | 256094 | 11580 | 999929 | 04 | 256165 | 11584 | 743835 | 58 |
| 3 | 263042 | 11398 | 999927 | 04 | 263115 | 11402 | 736885 | 57 |
| 4 | 269881 | 11221 | 999925 | 04 | 269956 | 11225 | 730044 | 56 |
| 5 | 276614 | 11050 | 999922 | 04 | 276691 | 11054 | 723309 | 55 |
| 6 | 283243 | 10883 | 999920 | 04 | 283323 | 10887 | 716677 | 54 |
| 7 | 289773 | 10721 | 999918 | 04 | 289856 | 10726 | 710144 | 53 |
| 8 | 296207 | 10565 | 999915 | 04 | 296292 | 10570 | 703708 | 52 |
| 9 | 302546 | 10413 | 999913 | 04 | 302634 | 10418 | 697366 | 51 |
| 10 | 308794 | 10266 | 999910 | 04 | 308884 | 10270 | 691116 | 50 |
| 11 | 8·314954 | 10122 | 9·999907 | 04 | 8·315046 | 10126 | 11·684954 | 49 |
| 12 | 321027 | 9982 | 999905 | 04 | 321122 | 9987 | 678878 | 48 |
| 13 | 327016 | 9847 | 999902 | 04 | 327114 | 9851 | 672886 | 47 |
| 14 | 332924 | 9714 | 999899 | 05 | 333025 | 9719 | 666975 | 46 |
| 15 | 338753 | 9586 | 999897 | 05 | 338856 | 9590 | 661144 | 45 |
| 16 | 344504 | 9460 | 999894 | 05 | 344610 | 9465 | 655390 | 44 |
| 17 | 350181 | 9338 | 999891 | 05 | 350289 | 9343 | 649711 | 43 |
| 18 | 355783 | 9219 | 999888 | 05 | 355895 | 9224 | 644105 | 42 |
| 19 | 361315 | 9103 | 999885 | 05 | 361430 | 9108 | 638570 | 41 |
| 20 | 366777 | 8990 | 999882 | 05 | 366895 | 8995 | 633105 | 40 |
| 21 | 8·372171 | 8880 | 9·999879 | 05 | 8·372292 | 8885 | 11·627708 | 39 |
| 22 | 377499 | 8772 | 999876 | 05 | 377622 | 8777 | 622378 | 38 |
| 23 | 382762 | 8667 | 999873 | 05 | 382889 | 8672 | 617111 | 37 |
| 24 | 387962 | 8564 | 999870 | 05 | 388092 | 8570 | 611908 | 36 |
| 25 | 393101 | 8464 | 999867 | 05 | 393234 | 8470 | 606766 | 35 |
| 26 | 368179 | 8366 | 999864 | 05 | 398315 | 8371 | 601685 | 34 |
| 27 | 403199 | 8271 | 999861 | 05 | 403338 | 8276 | 596662 | 33 |
| 28 | 408161 | 8177 | 999858 | 05 | 408304 | 8182 | 591696 | 32 |
| 29 | 413068 | 8086 | 999854 | 05 | 413213 | 8091 | 586787 | 31 |
| 30 | 417919 | 7996 | 999851 | 06 | 418068 | 8002 | 581932 | 30 |
| 31 | 8·422717 | 7909 | 9·999848 | 06 | 8·422869 | 7914 | 11·577131 | 29 |
| 32 | 427462 | 7823 | 999844 | 06 | 427618 | 7830 | 572382 | 28 |
| 33 | 432156 | 7740 | 999841 | 06 | 432315 | 7745 | 567685 | 27 |
| 34 | 436800 | 7657 | 999838 | 06 | 436962 | 7663 | 563038 | 26 |
| 35 | 441394 | 7577 | 999834 | 06 | 441560 | 7583 | 558440 | 25 |
| 36 | 445941 | 7499 | 999831 | 06 | 446110 | 7505 | 553890 | 24 |
| 37 | 450440 | 7422 | 999827 | 06 | 450613 | 7428 | 549387 | 23 |
| 38 | 454893 | 7346 | 999823 | 06 | 455070 | 7352 | 544930 | 22 |
| 39 | 459301 | 7273 | 999820 | 06 | 459481 | 7279 | 540519 | 21 |
| 40 | 463665 | 7200 | 999816 | 06 | 463849 | 7206 | 536151 | 20 |
| 41 | 8·467985 | 7129 | 9·999812 | 06 | 8·468172 | 7135 | 11·531828 | 19 |
| 42 | 472263 | 7060 | 999809 | 06 | 472454 | 7066 | 527546 | 18 |
| 43 | 476498 | 6991 | 999805 | 06 | 476693 | 6998 | 523307 | 17 |
| 44 | 480693 | 6924 | 999801 | 06 | 480892 | 6931 | 519108 | 16 |
| 45 | 484848 | 6859 | 999797 | 07 | 485050 | 6865 | 514950 | 15 |
| 46 | 488963 | 6794 | 999793 | 07 | 489170 | 6801 | 510830 | 14 |
| 47 | 493040 | 6731 | 999790 | 07 | 493250 | 6738 | 506750 | 13 |
| 48 | 497078 | 6669 | 999786 | 07 | 497293 | 6676 | 502707 | 12 |
| 49 | 501080 | 6608 | 999782 | 07 | 501298 | 6615 | 498702 | 11 |
| 50 | 505045 | 6548 | 999778 | 07 | 505267 | 6555 | 494733 | 10 |
| 51 | 8·508974 | 6489 | 9·999774 | 07 | 8·509200 | 6496 | 11·490800 | 9 |
| 52 | 512867 | 6431 | 999769 | 07 | 513098 | 6439 | 486902 | 8 |
| 53 | 516726 | 6375 | 999765 | 07 | 516961 | 6382 | 483039 | 7 |
| 54 | 520551 | 6319 | 999761 | 07 | 520790 | 6326 | 479210 | 6 |
| 55 | 524343 | 6264 | 999757 | 07 | 524586 | 6272 | 475414 | 5 |
| 56 | 528102 | 6211 | 999753 | 07 | 528349 | 6218 | 471651 | 4 |
| 57 | 531828 | 6158 | 999748 | 07 | 532080 | 6165 | 467920 | 3 |
| 58 | 535523 | 6106 | 999744 | 07 | 535779 | 6113 | 464221 | 2 |
| 59 | 539186 | 6055 | 999740 | 07 | 539447 | 6062 | 460553 | 1 |
| 60 | 542819 | 6004 | 999735 | 07 | 543084 | 6012 | 456916 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 8·542819 | 6004 | 9·999735 | 07 | 8·543084 | 6012 | 11·456916 | 60 |
| 1 | 546422 | 5955 | 999731 | 07 | 546091 | 5962 | 453909 | 59 |
| 2 | 549995 | 5906 | 999726 | 07 | 550268 | 5914 | 449732 | 58 |
| 3 | 553539 | 5858 | 999722 | 08 | 553817 | 5866 | 446183 | 57 |
| 4 | 557054 | 5811 | 999717 | 08 | 557336 | 5819 | 442664 | 56 |
| 5 | 560540 | 5765 | 999713 | 08 | 560828 | 5773 | 439172 | 55 |
| 6 | 563999 | 5719 | 999708 | 08 | 564291 | 5727 | 435709 | 54 |
| 7 | 567431 | 5674 | 999704 | 08 | 567727 | 5682 | 432273 | 53 |
| 8 | 570836 | 5630 | 999699 | 08 | 571137 | 5638 | 428863 | 52 |
| 9 | 574214 | 5587 | 999694 | 08 | 574520 | 5595 | 425480 | 51 |
| 10 | 577566 | 5544 | 999689 | 08 | 577877 | 5552 | 422123 | 50 |
| 11 | 8·580892 | 5502 | 9·999685 | 08 | 8·581208 | 5510 | 11·418792 | 49 |
| 12 | 584193 | 5460 | 999680 | 08 | 584514 | 5468 | 415486 | 48 |
| 13 | 587469 | 5419 | 999675 | 08 | 587795 | 5427 | 412205 | 47 |
| 14 | 590721 | 5379 | 999670 | 08 | 591051 | 5387 | 408949 | 46 |
| 15 | 593948 | 5339 | 999665 | 08 | 594283 | 5347 | 405717 | 45 |
| 16 | 597152 | 5300 | 999660 | 08 | 597492 | 5308 | 402508 | 44 |
| 17 | 600332 | 5261 | 999655 | 08 | 600677 | 5270 | 399323 | 43 |
| 18 | 603489 | 5223 | 999650 | 08 | 603839 | 5232 | 396161 | 42 |
| 19 | 606623 | 5186 | 999645 | 09 | 606978 | 5194 | 393022 | 41 |
| 20 | 609734 | 5149 | 999640 | 09 | 610094 | 5158 | 389906 | 40 |
| 21 | 8·612823 | 5112 | 9·999635 | 09 | 8·613189 | 5121 | 11·386811 | 39 |
| 22 | 615891 | 5076 | 999629 | 09 | 616262 | 5085 | 383738 | 38 |
| 23 | 618937 | 5041 | 999624 | 09 | 619313 | 5050 | 380687 | 37 |
| 24 | 621962 | 5006 | 999619 | 09 | 622343 | 5015 | 377657 | 36 |
| 25 | 624965 | 4972 | 999614 | 09 | 625352 | 4981 | 374648 | 35 |
| 26 | 627948 | 4938 | 999608 | 09 | 628340 | 4947 | 371660 | 34 |
| 27 | 630911 | 4904 | 999603 | 09 | 631308 | 4913 | 368692 | 33 |
| 28 | 633854 | 4871 | 999597 | 09 | 634256 | 4880 | 365744 | 32 |
| 29 | 636776 | 4839 | 999592 | 09 | 637184 | 4848 | 362816 | 31 |
| 30 | 639680 | 4806 | 999586 | 09 | 640093 | 4816 | 359907 | 30 |
| 31 | 8·642563 | 4775 | 9·999581 | 09 | 8·642982 | 4784 | 11·357018 | 29 |
| 32 | 645428 | 4743 | 999575 | 09 | 645853 | 4753 | 354147 | 28 |
| 33 | 648274 | 4712 | 999570 | 09 | 648704 | 4722 | 351296 | 27 |
| 34 | 651102 | 4682 | 999564 | 09 | 651537 | 4691 | 348463 | 26 |
| 35 | 653911 | 4652 | 999558 | 10 | 654352 | 4661 | 345648 | 25 |
| 36 | 656702 | 4622 | 999553 | 10 | 657149 | 4631 | 342851 | 24 |
| 37 | 659475 | 4592 | 999547 | 10 | 659928 | 4602 | 340072 | 23 |
| 38 | 662230 | 4563 | 999541 | 10 | 662689 | 4573 | 337311 | 22 |
| 39 | 664968 | 4535 | 999535 | 10 | 665433 | 4544 | 334567 | 21 |
| 40 | 667689 | 4506 | 999529 | 10 | 668160 | 4526 | 331840 | 20 |
| 41 | 8·670393 | 4479 | 9·999524 | 10 | 8·670870 | 4488 | 11·329130 | 19 |
| 42 | 673080 | 4451 | 999518 | 10 | 673563 | 4461 | 326437 | 18 |
| 43 | 675751 | 4424 | 999512 | 10 | 676239 | 4434 | 323761 | 17 |
| 44 | 678405 | 4397 | 999506 | 10 | 678900 | 4417 | 321100 | 16 |
| 45 | 681043 | 4370 | 999500 | 10 | 681544 | 4380 | 318456 | 15 |
| 46 | 683665 | 4344 | 999493 | 10 | 684172 | 4354 | 315828 | 14 |
| 47 | 686272 | 4318 | 999487 | 10 | 686784 | 4328 | 313216 | 13 |
| 48 | 688863 | 4292 | 999481 | 10 | 689381 | 4303 | 310619 | 12 |
| 49 | 691438 | 4267 | 999475 | 10 | 691963 | 4277 | 308037 | 11 |
| 50 | 693998 | 4242 | 999469 | 10 | 694529 | 4252 | 305471 | 10 |
| 51 | 8·696543 | 4217 | 9·999463 | 11 | 8·697081 | 4228 | 11·302919 | 9 |
| 52 | 699073 | 4192 | 999456 | 11 | 699617 | 4203 | 300383 | 8 |
| 53 | 701589 | 4168 | 999450 | 11 | 702139 | 4179 | 297861 | 7 |
| 54 | 704090 | 4144 | 999443 | 11 | 704646 | 4155 | 295354 | 6 |
| 55 | 706577 | 4121 | 999437 | 11 | 707140 | 4132 | 292860 | 5 |
| 56 | 709049 | 4097 | 999431 | 11 | 709618 | 4108 | 290382 | 4 |
| 57 | 711507 | 4074 | 999424 | 11 | 712083 | 4085 | 287917 | 3 |
| 58 | 713952 | 4051 | 999418 | 11 | 714534 | 4062 | 285465 | 2 |
| 59 | 716383 | 4029 | 999411 | 11 | 716972 | 4040 | 283028 | 1 |
| 60 | 718800 | 4006 | 999404 | 11 | 719396 | 4017 | 280604 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 8·718800 | 4006 | 9·999404 | 11 | 8·719396 | 4017 | 11·280604 | 60 |
| 1 | 721204 | 3984 | 999398 | 11 | 721806 | 3995 | 278194 | 59 |
| 2 | 723595 | 3962 | 999391 | 11 | 724204 | 3974 | 275796 | 58 |
| 3 | 725972 | 3941 | 999384 | 11 | 726588 | 3952 | 273412 | 57 |
| 4 | 728337 | 3919 | 999378 | 11 | 728959 | 3930 | 271041 | 56 |
| 5 | 730688 | 3898 | 999371 | 11 | 731317 | 3909 | 268683 | 55 |
| 6 | 733027 | 3877 | 999364 | 12 | 733663 | 3889 | 266337 | 54 |
| 7 | 735354 | 3857 | 999357 | 12 | 735996 | 3868 | 264004 | 53 |
| 8 | 737667 | 3836 | 999350 | 12 | 738317 | 3848 | 261683 | 52 |
| 9 | 739969 | 3816 | 999343 | 12 | 740626 | 3827 | 259374 | 51 |
| 10 | 742259 | 3796 | 999336 | 12 | 742922 | 3807 | 257078 | 50 |
| 11 | 8·744536 | 3776 | 9·999329 | 12 | 8·745207 | 3787 | 11·254793 | 49 |
| 12 | 746802 | 3756 | 999322 | 12 | 747479 | 3768 | 252521 | 48 |
| 13 | 749055 | 3737 | 999315 | 12 | 749740 | 3749 | 250260 | 47 |
| 14 | 751297 | 3717 | 999308 | 12 | 751989 | 3729 | 248011 | 46 |
| 15 | 753528 | 3698 | 999301 | 12 | 754227 | 3710 | 245773 | 45 |
| 16 | 755747 | 3679 | 999294 | 12 | 756453 | 3692 | 243547 | 44 |
| 17 | 757955 | 3661 | 999286 | 12 | 758668 | 3673 | 241332 | 43 |
| 18 | 760151 | 3642 | 999279 | 12 | 760872 | 3655 | 239128 | 42 |
| 19 | 762337 | 3624 | 999272 | 12 | 763065 | 3636 | 236935 | 41 |
| 20 | 764511 | 3606 | 999265 | 12 | 765246 | 3618 | 234754 | 40 |
| 21 | 8·766675 | 3588 | 9·999257 | 12 | 8·767417 | 3600 | 11·232583 | 39 |
| 22 | 768828 | 3570 | 999250 | 13 | 769578 | 3583 | 230422 | 38 |
| 23 | 770970 | 3553 | 999242 | 13 | 771727 | 3565 | 228273 | 37 |
| 24 | 773101 | 3535 | 999235 | 13 | 773866 | 3548 | 226134 | 36 |
| 25 | 775223 | 3518 | 999227 | 13 | 775995 | 3531 | 224005 | 35 |
| 26 | 777333 | 3501 | 999220 | 13 | 778114 | 3514 | 221886 | 34 |
| 27 | 779434 | 3484 | 999212 | 13 | 780222 | 3497 | 219778 | 33 |
| 28 | 781524 | 3467 | 999205 | 13 | 782320 | 3480 | 217680 | 32 |
| 29 | 783605 | 3451 | 999197 | 13 | 784408 | 3464 | 215592 | 31 |
| 30 | 785675 | 3431 | 999189 | 13 | 786486 | 3447 | 213514 | 30 |
| 31 | 8·787736 | 3418 | 9·999181 | 13 | 8·788554 | 3431 | 11·211446 | 29 |
| 32 | 789787 | 3402 | 999174 | 13 | 790613 | 3414 | 209387 | 28 |
| 33 | 791828 | 3386 | 999166 | 13 | 792662 | 3399 | 207338 | 27 |
| 34 | 793859 | 3370 | 999158 | 13 | 794701 | 3383 | 205299 | 26 |
| 35 | 795881 | 3354 | 999150 | 13 | 796731 | 3368 | 203269 | 25 |
| 36 | 797894 | 3339 | 999142 | 13 | 798752 | 3352 | 201248 | 24 |
| 37 | 799897 | 3323 | 999134 | 13 | 800763 | 3337 | 199237 | 23 |
| 38 | 801892 | 3308 | 999126 | 13 | 802765 | 3322 | 197235 | 22 |
| 39 | 803876 | 3293 | 999118 | 13 | 804758 | 3307 | 195242 | 21 |
| 40 | 805852 | 3278 | 999110 | 13 | 806742 | 3292 | 193258 | 20 |
| 41 | 8·807819 | 3263 | 9·999102 | 13 | 8·808717 | 3278 | 11·191283 | 19 |
| 42 | 809777 | 3249 | 999094 | 14 | 810683 | 3262 | 189317 | 18 |
| 43 | 811726 | 3234 | 999086 | 14 | 812641 | 3248 | 187359 | 17 |
| 44 | 813667 | 3219 | 999077 | 14 | 814589 | 3233 | 185411 | 16 |
| 45 | 815599 | 3205 | 999069 | 14 | 816529 | 3219 | 183471 | 15 |
| 46 | 817522 | 3191 | 999061 | 14 | 818461 | 3205 | 181539 | 14 |
| 47 | 819436 | 3177 | 999053 | 14 | 820384 | 3191 | 179616 | 13 |
| 48 | 821343 | 3163 | 999044 | 14 | 822298 | 3177 | 177702 | 12 |
| 49 | 823240 | 3149 | 999036 | 14 | 824205 | 3163 | 175795 | 11 |
| 50 | 825130 | 3135 | 999027 | 14 | 826103 | 3150 | 173897 | 10 |
| 51 | 8·827011 | 3122 | 9·999019 | 14 | 8·827992 | 3136 | 11·172008 | 9 |
| 52 | 828884 | 3108 | 999010 | 14 | 829874 | 3123 | 170126 | 8 |
| 53 | 830749 | 3095 | 999002 | 14 | 831748 | 3110 | 168252 | 7 |
| 54 | 832607 | 3082 | 998993 | 14 | 833613 | 3096 | 166387 | 6 |
| 55 | 834456 | 3069 | 998984 | 14 | 835471 | 3083 | 164529 | 5 |
| 56 | 836297 | 3056 | 998976 | 14 | 837321 | 3070 | 162679 | 4 |
| 57 | 838130 | 3043 | 998967 | 15 | 839163 | 3057 | 160837 | 3 |
| 58 | 839956 | 3030 | 998958 | 15 | 840998 | 3045 | 159002 | 2 |
| 59 | 841774 | 3017 | 998950 | 15 | 842825 | 3032 | 157175 | 1 |
| 60 | 843585 | 3000 | 998941 | 15 | 844644 | 3019 | 155356 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

86 Degrees.

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 8·843585 | 3005 | 9·998941 | 15 | 8·844644 | 3019 | 11·155356 | 60 |
| 1 | 845387 | 2992 | 998932 | 15 | 846455 | 3007 | 153545 | 59 |
| 2 | 847183 | 2980 | 998923 | 15 | 848260 | 2995 | 151740 | 58 |
| 3 | 848971 | 2967 | 998914 | 15 | 850057 | 2982 | 149943 | 57 |
| 4 | 850751 | 2955 | 998905 | 15 | 851846 | 2970 | 148154 | 56 |
| 5 | 852525 | 2943 | 998896 | 15 | 853628 | 2958 | 146372 | 55 |
| 6 | 854291 | 2931 | 998887 | 15 | 855403 | 2946 | 144597 | 54 |
| 7 | 856049 | 2919 | 998878 | 15 | 857171 | 2935 | 142829 | 53 |
| 8 | 857801 | 2907 | 998869 | 15 | 858932 | 2923 | 141068 | 52 |
| 9 | 859546 | 2896 | 998860 | 15 | 860686 | 2911 | 139314 | 51 |
| 10 | 861283 | 2884 | 998851 | 15 | 862433 | 2900 | 137567 | 50 |
| 11 | 8·863014 | 2873 | 9·998841 | 15 | 8·864173 | 2888 | 11·135827 | 49 |
| 12 | 864738 | 2861 | 998832 | 15 | 865906 | 2877 | 134094 | 48 |
| 13 | 866455 | 2850 | 998823 | 16 | 867632 | 2866 | 132368 | 47 |
| 14 | 868165 | 2839 | 998813 | 16 | 869351 | 2854 | 130649 | 46 |
| 15 | 869868 | 2828 | 998804 | 16 | 871064 | 2843 | 128936 | 45 |
| 16 | 871565 | 2817 | 998795 | 16 | 872770 | 2832 | 127230 | 44 |
| 17 | 873255 | 2806 | 998785 | 16 | 874469 | 2821 | 125531 | 43 |
| 18 | 874938 | 2795 | 998776 | 16 | 876162 | 2811 | 123838 | 42 |
| 19 | 876615 | 2786 | 998766 | 16 | 877849 | 2800 | 122151 | 41 |
| 20 | 878285 | 2773 | 998757 | 16 | 879529 | 2789 | 120471 | 40 |
| 21 | 8·879949 | 2763 | 9·998747 | 16 | 8·881202 | 2779 | 11·118798 | 39 |
| 22 | 881607 | 2752 | 998738 | 16 | 882869 | 2768 | 117131 | 38 |
| 23 | 883258 | 2742 | 998728 | 16 | 884530 | 2758 | 115470 | 37 |
| 24 | 884903 | 2731 | 998718 | 16 | 886185 | 2747 | 113815 | 36 |
| 25 | 886542 | 2721 | 998708 | 16 | 887833 | 2737 | 112167 | 35 |
| 26 | 888174 | 2711 | 998699 | 16 | 889476 | 2727 | 110524 | 34 |
| 27 | 889801 | 2700 | 998689 | 16 | 891112 | 2717 | 108888 | 33 |
| 28 | 891421 | 2690 | 998679 | 16 | 892742 | 2707 | 107258 | 32 |
| 29 | 893035 | 2680 | 998669 | 17 | 894366 | 2697 | 105634 | 31 |
| 30 | 894643 | 2670 | 998659 | 17 | 895984 | 2687 | 104016 | 30 |
| 31 | 8·896246 | 2660 | 9·998649 | 17 | 8·897596 | 2677 | 11·102404 | 29 |
| 32 | 897842 | 2651 | 998639 | 17 | 899203 | 2667 | 100797 | 28 |
| 33 | 899432 | 2641 | 998629 | 17 | 900803 | 2658 | 099197 | 27 |
| 34 | 901017 | 2631 | 998619 | 17 | 902398 | 2648 | 097602 | 26 |
| 35 | 902596 | 2622 | 998609 | 17 | 903987 | 2638 | 096013 | 25 |
| 36 | 904169 | 2612 | 998599 | 17 | 905570 | 2629 | 094430 | 24 |
| 37 | 905736 | 2603 | 998589 | 17 | 907147 | 2620 | 092853 | 23 |
| 38 | 907297 | 2593 | 998578 | 17 | 908719 | 2610 | 091281 | 22 |
| 39 | 908853 | 2584 | 998568 | 17 | 910285 | 2601 | 089715 | 21 |
| 40 | 910404 | 2575 | 998558 | 17 | 911846 | 2592 | 088154 | 20 |
| 41 | 8·911949 | 2566 | 9·998548 | 17 | 8·913401 | 2583 | 11·086599 | 19 |
| 42 | 913488 | 2556 | 998537 | 17 | 914951 | 2574 | 085049 | 18 |
| 43 | 915022 | 2547 | 998527 | 17 | 916495 | 2565 | 083505 | 17 |
| 44 | 916550 | 2538 | 998516 | 18 | 918034 | 2556 | 081966 | 16 |
| 45 | 918073 | 2529 | 998506 | 18 | 919568 | 2547 | 080432 | 15 |
| 46 | 919591 | 2520 | 998495 | 18 | 921096 | 2538 | 078904 | 14 |
| 47 | 921103 | 2512 | 998485 | 18 | 922619 | 2530 | 077381 | 13 |
| 48 | 922610 | 2503 | 998474 | 18 | 924136 | 2521 | 075864 | 12 |
| 49 | 924112 | 2494 | 998464 | 18 | 925649 | 2512 | 074351 | 11 |
| 50 | 925609 | 2486 | 998453 | 18 | 927156 | 2503 | 072844 | 10 |
| 51 | 8·927100 | 2477 | 9·998442 | 18 | 8·928658 | 2495 | 11·071342 | 9 |
| 52 | 928587 | 2469 | 998431 | 18 | 930155 | 2486 | 069845 | 8 |
| 53 | 930068 | 2460 | 998421 | 18 | 931647 | 2478 | 068353 | 7 |
| 54 | 931544 | 2452 | 998410 | 18 | 933134 | 2470 | 066866 | 6 |
| 55 | 933015 | 2443 | 998399 | 18 | 934616 | 2461 | 065384 | 5 |
| 56 | 934481 | 2435 | 998388 | 18 | 936093 | 2453 | 063907 | 4 |
| 57 | 935942 | 2427 | 998377 | 18 | 937565 | 2445 | 062435 | 3 |
| 58 | 937398 | 2419 | 998366 | 18 | 939032 | 2437 | 060968 | 2 |
| 59 | 938850 | 2411 | 998355 | 18 | 940494 | 2430 | 059506 | 1 |
| 60 | 940296 | 2403 | 998344 | 18 | 941952 | 2421 | 058048 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 8·940296 | 2403 | 9·998344 | 19 | 8·941952 | 2421 | 11·058048 | 60 |
| 1 | 941738 | 2394 | 998333 | 19 | 943404 | 2413 | 056596 | 59 |
| 2 | 943174 | 2387 | 998322 | 19 | 944852 | 2405 | 055148 | 58 |
| 3 | 944606 | 2379 | 998311 | 19 | 946295 | 2397 | 053705 | 57 |
| 4 | 946034 | 2371 | 998300 | 19 | 947734 | 2390 | 052266 | 56 |
| 5 | 947456 | 2363 | 998289 | 19 | 949168 | 3282 | 050832 | 55 |
| 6 | 948874 | 2355 | 998277 | 19 | 950597 | 2374 | 049403 | 54 |
| 7 | 950287 | 2348 | 998266 | 19 | 952021 | 2366 | 047979 | 53 |
| 8 | 951696 | 2340 | 998255 | 19 | 953441 | 2360 | 046559 | 52 |
| 9 | 953100 | 2332 | 998243 | 19 | 954856 | 2351 | 045144 | 51 |
| 10 | 954499 | 2325 | 998232 | 19 | 956267 | 2344 | 043733 | 50 |
| 11 | 8·955894 | 2317 | 9·998220 | 19 | 8·957674 | 2337 | 11·042326 | 49 |
| 12 | 957284 | 2310 | 998209 | 19 | 959075 | 2329 | 040925 | 48 |
| 13 | 958670 | 2302 | 998197 | 19 | 960473 | 2323 | 039527 | 47 |
| 14 | 960052 | 2295 | 998186 | 19 | 961866 | 2314 | 038134 | 46 |
| 15 | 961429 | 2288 | 998174 | 19 | 963255 | 2307 | 036745 | 45 |
| 16 | 962801 | 2280 | 998163 | 19 | 964639 | 2300 | 035361 | 44 |
| 17 | 964170 | 2273 | 998151 | 19 | 966019 | 2293 | 033981 | 43 |
| 18 | 965534 | 2266 | 998139 | 20 | 967394 | 2286 | 032606 | 42 |
| 19 | 966893 | 2259 | 998128 | 20 | 968766 | 2279 | 031234 | 41 |
| 20 | 968249 | 2252 | 998116 | 20 | 970133 | 2271 | 029867 | 40 |
| 21 | 8·969600 | 2244 | 9·998104 | 20 | 8·971496 | 2265 | 11·028504 | 39 |
| 22 | 970947 | 2238 | 998092 | 20 | 972855 | 2257 | 027145 | 38 |
| 23 | 972289 | 2231 | 998080 | 20 | 974209 | 2251 | 025791 | 37 |
| 24 | 973628 | 2224 | 998068 | 20 | 975560 | 2244 | 024440 | 36 |
| 25 | 974962 | 2217 | 998056 | 20 | 976906 | 2237 | 023094 | 35 |
| 26 | 976293 | 2210 | 998044 | 20 | 978248 | 2230 | 021752 | 34 |
| 27 | 977619 | 2203 | 998032 | 20 | 979586 | 2223 | 020414 | 33 |
| 28 | 978941 | 2197 | 998020 | 20 | 980921 | 2217 | 019079 | 32 |
| 29 | 980259 | 2190 | 998008 | 20 | 982251 | 2210 | 017749 | 31 |
| 30 | 981573 | 2183 | 997996 | 20 | 983577 | 2204 | 016423 | 30 |
| 31 | 8·982883 | 2177 | 9·997984 | 20 | 8·984899 | 2197 | 11·015101 | 29 |
| 32 | 984189 | 2170 | 997972 | 20 | 986217 | 2191 | 013783 | 28 |
| 33 | 985491 | 2163 | 997959 | 20 | 987532 | 2184 | 012468 | 27 |
| 34 | 986789 | 2157 | 997947 | 20 | 988842 | 2178 | 011158 | 26 |
| 35 | 988083 | 2150 | 997935 | 21 | 990149 | 2171 | 009851 | 25 |
| 36 | 989374 | 2144 | 997922 | 21 | 991451 | 2165 | 008549 | 24 |
| 37 | 990660 | 2138 | 997910 | 21 | 992750 | 2158 | 007250 | 23 |
| 38 | 991943 | 2131 | 997897 | 21 | 994045 | 2152 | 005955 | 22 |
| 39 | 993222 | 2125 | 997885 | 21 | 995337 | 2146 | 004663 | 21 |
| 40 | 994497 | 2119 | 997872 | 21 | 996624 | 2140 | 003376 | 20 |
| 41 | 8·995768 | 2112 | 9·997860 | 21 | 8·997908 | 2134 | 11·002092 | 19 |
| 42 | 997036 | 2106 | 997847 | 21 | 999188 | 2127 | 000812 | 18 |
| 43 | 998299 | 2100 | 997835 | 21 | 000465 | 2121 | 10·999535 | 17 |
| 44 | 999560 | 2094 | 997822 | 21 | 001738 | 2115 | 998262 | 16 |
| 45 | 9·000816 | 2087 | 997809 | 21 | 003007 | 2109 | 996993 | 15 |
| 46 | 002069 | 2082 | 997797 | 21 | 004272 | 2103 | 995728 | 14 |
| 47 | 003318 | 2076 | 997784 | 21 | 005534 | 2097 | 994466 | 13 |
| 48 | 004563 | 2070 | 997771 | 21 | 006792 | 2091 | 993208 | 12 |
| 49 | 005805 | 2064 | 997758 | 21 | 008047 | 2085 | 991953 | 11 |
| 50 | 007044 | 2058 | 997745 | 21 | 009298 | 2080 | 990702 | 10 |
| 51 | 8·008278 | 2052 | 8·997732 | 21 | 8·010546 | 2074 | 10·989454 | 9 |
| 52 | 009510 | 2046 | 997719 | 21 | 011790 | 2068 | 988210 | 8 |
| 53 | 010737 | 2040 | 997706 | 21 | 013031 | 2062 | 986969 | 7 |
| 54 | 011962 | 2034 | 997693 | 22 | 014268 | 2056 | 985732 | 6 |
| 55 | 013182 | 2029 | 997680 | 22 | 015502 | 2051 | 984498 | 5 |
| 56 | 014400 | 2023 | 997667 | 22 | 016732 | 2045 | 983268 | 4 |
| 57 | 015613 | 2017 | 997654 | 22 | 017959 | 2040 | 982041 | 3 |
| 58 | 016824 | 2012 | 997641 | 22 | 019183 | 2033 | 980817 | 2 |
| 59 | 018031 | 2006 | 997628 | 22 | 020403 | 2028 | 979597 | 1 |
| 60 | 019235 | 2000 | 997614 | 22 | 021620 | 2023 | 978380 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·019235 | 2000 | 9·997614 | 22 | 9·021620 | 2023 | 10·978380 | 60 |
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| 3 | 022825 | 1984 | 997574 | 22 | 025251 | 2006 | 974749 | 57 |
| 4 | 024016 | 1978 | 997561 | 22 | 026455 | 2000 | 973545 | 56 |
| 5 | 025203 | 1973 | 997547 | 22 | 027655 | 1995 | 972345 | 55 |
| 6 | 026386 | 1967 | 997534 | 23 | 028852 | 1990 | 971148 | 54 |
| 7 | 027567 | 1962 | 997520 | 23 | 030046 | 1985 | 969954 | 53 |
| 8 | 028744 | 1957 | 997507 | 23 | 031237 | 1979 | 968763 | 52 |
| 9 | 029918 | 1951 | 997493 | 23 | 032425 | 1974 | 967575 | 51 |
| 10 | 031089 | 1947 | 997480 | 23 | 033609 | 1969 | 966391 | 50 |
| 11 | 9·032257 | 1941 | 9·997466 | 23 | 9·034791 | 1964 | 10·965209 | 49 |
| 12 | 033421 | 1936 | 997452 | 23 | 035969 | 1958 | 964031 | 48 |
| 13 | 034582 | 1930 | 997439 | 23 | 037144 | 1953 | 962856 | 47 |
| 14 | 035741 | 1925 | 997425 | 23 | 038316 | 1948 | 961684 | 46 |
| 15 | 036896 | 1920 | 997411 | 23 | 039485 | 1943 | 960515 | 45 |
| 16 | 038048 | 1915 | 997397 | 23 | 040651 | 1938 | 959349 | 44 |
| 17 | 039197 | 1910 | 997383 | 23 | 041813 | 1933 | 958187 | 43 |
| 18 | 040342 | 1905 | 997369 | 23 | 042973 | 1928 | 957027 | 42 |
| 19 | 041485 | 1899 | 997355 | 23 | 044130 | 1923 | 955870 | 41 |
| 20 | 042625 | 1894 | 997341 | 23 | 045284 | 1918 | 954716 | 40 |
| 21 | 9 043762 | 1889 | 9·997327 | 24 | 9·046434 | 1913 | 10·953566 | 39 |
| 22 | 044895 | 1884 | 997313 | 24 | 047582 | 1908 | 952418 | 38 |
| 23 | 046026 | 1879 | 997299 | 24 | 048727 | 1903 | 951273 | 37 |
| 24 | 047154 | 1875 | 997285 | 24 | 049869 | 1898 | 950131 | 36 |
| 25 | 048279 | 1970 | 997271 | 24 | 051008 | 1893 | 948992 | 35 |
| 26 | 049400 | 1865 | 997257 | 24 | 052144 | 1889 | 947856 | 34 |
| 27 | 050519 | 1860 | 997242 | 24 | 053277 | 1884 | 946723 | 33 |
| 28 | 051635 | 1855 | 997228 | 24 | 054407 | 1879 | 945593 | 32 |
| 29 | 052749 | 1850 | 997214 | 24 | 055535 | 1874 | 944465 | 31 |
| 30 | 053859 | 1845 | 997199 | 24 | 056659 | 1870 | 943341 | 30 |
| 31 | 054966 | 1841 | 9·997185 | 24 | 9·057781 | 1865 | 10·942219 | 29 |
| 32 | 056071 | 1836 | 997170 | 24 | 058900 | 1869 | 941100 | 28 |
| 33 | 057172 | 1831 | 997156 | 24 | 060016 | 1855 | 939984 | 27 |
| 34 | 058271 | 1827 | 997141 | 24 | 061130 | 1851 | 938870 | 26 |
| 35 | 059367 | 1822 | 997127 | 24 | 062240 | 1846 | 937760 | 25 |
| 36 | 060460 | 1817 | 997112 | 24 | 063348 | 1842 | 936652 | 24 |
| 37 | 061551 | 1813 | 997098 | 24 | 064453 | 1837 | 935547 | 23 |
| 38 | 062639 | 1808 | 997083 | 25 | 065556 | 1833 | 934444 | 22 |
| 39 | 063724 | 1804 | 997068 | 25 | 066655 | 1828 | 833345 | 21 |
| 40 | 064806 | 1799 | 997053 | 25 | 067752 | 1824 | 932248 | 20 |
| 41 | 9·065885 | 1794 | 9·997039 | 25 | 9·068846 | 1819 | 10·931154 | 19 |
| 42 | 066962 | 1790 | 997024 | 25 | 069938 | 1815 | 930062 | 18 |
| 43 | 068036 | 1786 | 997009 | 25 | 071027 | 1810 | 928973 | 17 |
| 44 | 069107 | 1781 | 996994 | 25 | 072113 | 1806 | 927887 | 16 |
| 45 | 070176 | 1777 | 996979 | 25 | 073197 | 1802 | 926803 | 15 |
| 46 | 071242 | 1772 | 996964 | 25 | 074278 | 1797 | 925722 | 14 |
| 47 | 072306 | 1768 | 996949 | 25 | 075356 | 1793 | 924644 | 13 |
| 48 | 073366 | 1763 | 996934 | 25 | 076432 | 1789 | 923568 | 12 |
| 49 | 074424 | 1759 | 996919 | 25 | 077505 | 1784 | 922495 | 11 |
| 50 | 075480 | 1755 | 996904 | 25 | 078576 | 1780 | 921424 | 10 |
| 51 | 9·076533 | 1750 | 9·996889 | 25 | 9·079644 | 1776 | 10·920356 | 9 |
| 52 | 077583 | 1746 | 996874 | 25 | 080710 | 1772 | 919290 | 8 |
| 53 | 078631 | 1742 | 996858 | 25 | 081773 | 1767 | 918227 | 7 |
| 54 | 079676 | 1738 | 996843 | 25 | 082833 | 1763 | 917167 | 6 |
| 55 | 080719 | 1733 | 996828 | 25 | 083891 | 1759 | 916109 | 5 |
| 56 | 081759 | 1729 | 996812 | 26 | 084947 | 1755 | 915053 | 4 |
| 57 | 082797 | 1725 | 996797 | 26 | 086000 | 1751 | 914000 | 3 |
| 58 | 083832 | 1721 | 996782 | 26 | 087050 | 1747 | 912950 | 2 |
| 59 | 084864 | 1717 | 996766 | 26 | 088098 | 1743 | 911902 | 1 |
| 60 | 085894 | 1713 | 996751 | 26 | 089144 | 1738 | 910856 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·085894 | 1713 | 9·996751 | 26 | 9·089144 | 1738 | 10·910856 | 60 |
| 1 | 086922 | 1709 | 996735 | 26 | 090187 | 1734 | 909813 | 59 |
| 2 | 087947 | 1704 | 996720 | 26 | 091228 | 1730 | 908772 | 58 |
| 3 | 088970 | 1700 | 996704 | 26 | 092266 | 1727 | 907734 | 57 |
| 4 | 089990 | 1696 | 996688 | 26 | 093302 | 1722 | 906698 | 56 |
| 5 | 091008 | 1692 | 996673 | 26 | 094336 | 1719 | 905664 | 55 |
| 6 | 092024 | 1688 | 996657 | 26 | 095367 | 1715 | 904633 | 54 |
| 7 | 093037 | 1684 | 996641 | 26 | 096395 | 1711 | 903605 | 53 |
| 8 | 094047 | 1680 | 996625 | 26 | 097422 | 1707 | 902578 | 52 |
| 9 | 095056 | 1676 | 996610 | 26 | 098446 | 1703 | 901554 | 51 |
| 10 | 096062 | 1673 | 996594 | 26 | 099468 | 1699 | 900532 | 50 |
| 11 | 9·097065 | 1668 | 9·996578 | 27 | 9·100487 | 1695 | 10·899513 | 49 |
| 12 | 098066 | 1665 | 996562 | 27 | 101504 | 1691 | 898496 | 48 |
| 13 | 099065 | 1661 | 996546 | 27 | 102519 | 1687 | 897481 | 47 |
| 14 | 100062 | 1657 | 996530 | 27 | 103532 | 1684 | 896468 | 46 |
| 15 | 101056 | 1653 | 996514 | 27 | 104542 | 1680 | 895458 | 45 |
| 16 | 102048 | 1649 | 996498 | 27 | 105550 | 1676 | 894450 | 44 |
| 17 | 103037 | 1645 | 996482 | 27 | 106556 | 1672 | 893444 | 43 |
| 18 | 104025 | 1641 | 996465 | 27 | 107559 | 1669 | 892441 | 42 |
| 19 | 105010 | 1638 | 996449 | 27 | 108560 | 1665 | 891440 | 41 |
| 20 | 105992 | 1634 | 996433 | 27 | 109559 | 1661 | 890441 | 40 |
| 21 | 9·106973 | 1630 | 9·996417 | 27 | 9·110556 | 1658 | 10·889444 | 39 |
| 22 | 107951 | 1627 | 996400 | 27 | 111551 | 1654 | 888449 | 38 |
| 23 | 108927 | 1623 | 996384 | 27 | 112543 | 1650 | 887457 | 37 |
| 24 | 109901 | 1619 | 996368 | 27 | 113533 | 1646 | 886467 | 36 |
| 25 | 110873 | 1616 | 996351 | 27 | 114521 | 1643 | 885479 | 35 |
| 26 | 111842 | 1612 | 996335 | 27 | 115507 | 1639 | 884493 | 34 |
| 27 | 112809 | 1608 | 996318 | 27 | 116491 | 1636 | 883509 | 33 |
| 28 | 113774 | 1605 | 996302 | 28 | 117472 | 1632 | 882528 | 32 |
| 29 | 114737 | 1601 | 996285 | 28 | 118452 | 1629 | 881548 | 31 |
| 30 | 115698 | 1597 | 996269 | 28 | 119429 | 1625 | 880571 | 30 |
| 31 | 9·116656 | 1594 | 9·996252 | 28 | 9·120404 | 1622 | 10·879596 | 29 |
| 32 | 117613 | 1590 | 996235 | 28 | 121377 | 1618 | 878623 | 28 |
| 33 | 118567 | 1587 | 996219 | 28 | 122348 | 1615 | 877652 | 27 |
| 34 | 119519 | 1583 | 996202 | 28 | 123317 | 1611 | 876683 | 26 |
| 35 | 120469 | 1580 | 996185 | 28 | 124284 | 1607 | 875716 | 25 |
| 36 | 121417 | 1576 | 996168 | 28 | 125249 | 1604 | 874751 | 24 |
| 37 | 122362 | 1573 | 996151 | 28 | 126211 | 1601 | 873789 | 23 |
| 38 | 123306 | 1569 | 996134 | 28 | 127172 | 1597 | 872828 | 22 |
| 39 | 124248 | 1566 | 996117 | 28 | 128130 | 1594 | 871870 | 21 |
| 40 | 125187 | 1562 | 996100 | 28 | 129087 | 1591 | 870913 | 20 |
| 41 | 9·126125 | 1559 | 9·996083 | 29 | 9·130041 | 1587 | 10·869959 | 19 |
| 42 | 127060 | 1556 | 996066 | 29 | 130994 | 1584 | 869006 | 18 |
| 43 | 127993 | 1552 | 996049 | 29 | 131944 | 1581 | 868056 | 17 |
| 44 | 128925 | 1549 | 996032 | 29 | 132893 | 1577 | 867107 | 16 |
| 45 | 129854 | 1545 | 996015 | 29 | 133839 | 1574 | 866161 | 15 |
| 46 | 130781 | 1542 | 995998 | 29 | 134784 | 1571 | 865216 | 14 |
| 47 | 131706 | 1539 | 995980 | 29 | 135726 | 1567 | 864274 | 13 |
| 48 | 132630 | 1535 | 995963 | 29 | 136667 | 1564 | 863333 | 12 |
| 49 | 133551 | 1532 | 995946 | 29 | 137605 | 1561 | 862395 | 11 |
| 50 | 134470 | 1529 | 995928 | 29 | 138542 | 1558 | 861458 | 10 |
| 51 | 9·135387 | 1525 | 9·995911 | 29 | 9·139476 | 1555 | 10·860524 | 9 |
| 52 | 136303 | 1522 | 995894 | 29 | 140409 | 1551 | 859591 | 8 |
| 53 | 137216 | 1519 | 995876 | 29 | 141340 | 1548 | 858660 | 7 |
| 54 | 138128 | 1516 | 995859 | 29 | 142269 | 1545 | 857731 | 6 |
| 55 | 139037 | 1512 | 995841 | 29 | 143196 | 1542 | 856804 | 5 |
| 56 | 139944 | 1509 | 995823 | 29 | 144121 | 1539 | 855879 | 4 |
| 57 | 140850 | 1506 | 995806 | 29 | 145044 | 1535 | 854956 | 3 |
| 58 | 141754 | 1503 | 995788 | 29 | 145966 | 1532 | 854034 | 2 |
| 59 | 142655 | 1500 | 995771 | 29 | 146885 | 1529 | 853115 | 1 |
| 60 | 143555 | 1496 | 995753 | 29 | 147803 | 1526 | 852197 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·143555 | 1496 | 9·995753 | 30 | 9·147803 | 1526 | 10·852197 | 60 |
| 1 | 144453 | 1493 | 995735 | 30 | 148718 | 1523 | 851282 | 59 |
| 2 | 145349 | 1490 | 995717 | 30 | 149632 | 1520 | 850368 | 58 |
| 3 | 146243 | 1487 | 995699 | 30 | 150544 | 1517 | 849456 | 57 |
| 4 | 147136 | 1484 | 995681 | 30 | 151454 | 1514 | 848546 | 56 |
| 5 | 148026 | 1481 | 995664 | 30 | 152363 | 1511 | 847637 | 55 |
| 6 | 148915 | 1478 | 995646 | 30 | 153269 | 1508 | 846731 | 54 |
| 7 | 149802 | 1475 | 995628 | 30 | 154174 | 1505 | 845826 | 53 |
| 8 | 150686 | 1472 | 995610 | 30 | 155077 | 1502 | 844923 | 52 |
| 9 | 151569 | 1469 | 995591 | 30 | 155978 | 1499 | 844022 | 51 |
| 10 | 152451 | 1466 | 995573 | 30 | 156877 | 1496 | 843123 | 50 |
| 11 | 9·153330 | 1463 | 9·995555 | 30 | 9·157775 | 1493 | 10·842225 | 49 |
| 12 | 154208 | 1460 | 995537 | 30 | 158671 | 1490 | 841329 | 48 |
| 13 | 155083 | 1457 | 995519 | 30 | 159565 | 1487 | 840435 | 47 |
| 14 | 155957 | 1454 | 995501 | 31 | 160457 | 1484 | 839543 | 46 |
| 15 | 156830 | 1451 | 995482 | 31 | 161347 | 1481 | 838653 | 45 |
| 16 | 157700 | 1448 | 995464 | 31 | 162236 | 1479 | 837764 | 44 |
| 17 | 158569 | 1445 | 995446 | 31 | 163123 | 1476 | 836877 | 43 |
| 18 | 159435 | 1442 | 995427 | 31 | 164008 | 1473 | 835992 | 42 |
| 19 | 160301 | 1439 | 995409 | 31 | 164892 | 1470 | 835108 | 41 |
| 20 | 161164 | 1436 | 995390 | 31 | 165774 | 1467 | 834226 | 40 |
| 21 | 9·162025 | 1433 | 9·995372 | 31 | 9·166654 | 1464 | 10·833346 | 39 |
| 22 | 162885 | 1430 | 995353 | 31 | 167532 | 1461 | 832468 | 38 |
| 23 | 163743 | 1427 | 995334 | 31 | 168409 | 1458 | 831591 | 37 |
| 24 | 164600 | 1424 | 995316 | 31 | 169284 | 1455 | 830716 | 36 |
| 25 | 165454 | 1422 | 995297 | 31 | 170157 | 1453 | 829843 | 35 |
| 26 | 166307 | 1419 | 995278 | 31 | 171029 | 1450 | 828971 | 34 |
| 27 | 167159 | 1416 | 995260 | 31 | 171899 | 1447 | 828101 | 33 |
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| 29 | 168856 | 1410 | 995222 | 32 | 173634 | 1442 | 826366 | 31 |
| 30 | 169702 | 1407 | 995203 | 32 | 174499 | 1439 | 825501 | 30 |
| 31 | 9·170547 | 1405 | 9·995184 | 32 | 9·175362 | 1436 | 10·824638 | 29 |
| 32 | 171389 | 1402 | 995165 | 32 | 176224 | 1433 | 823776 | 28 |
| 33 | 172230 | 1399 | 995146 | 32 | 177084 | 1431 | 822916 | 27 |
| 34 | 173070 | 1396 | 995127 | 32 | 177942 | 1428 | 822058 | 26 |
| 35 | 173908 | 1394 | 995108 | 32 | 178799 | 1425 | 821201 | 25 |
| 36 | 174744 | 1391 | 995089 | 32 | 179655 | 1423 | 820345 | 24 |
| 37 | 175578 | 1388 | 995070 | 32 | 180508 | 1420 | 819492 | 23 |
| 38 | 176411 | 1386 | 995051 | 32 | 181360 | 1417 | 818640 | 22 |
| 39 | 177242 | 1383 | 995032 | 32 | 182211 | 1415 | 817789 | 21 |
| 40 | 178072 | 1380 | 995013 | 32 | 183059 | 1412 | 816941 | 20 |
| 41 | 9·178900 | 1377 | 9·994993 | 32 | 9·183907 | 1409 | 10·816093 | 19 |
| 42 | 179726 | 1374 | 994974 | 32 | 184752 | 1407 | 815248 | 18 |
| 43 | 180551 | 1372 | 994955 | 32 | 185597 | 1404 | 814403 | 17 |
| 44 | 181374 | 1369 | 994935 | 32 | 186439 | 1402 | 813561 | 16 |
| 45 | 182196 | 1366 | 994916 | 33 | 187280 | 1399 | 812720 | 15 |
| 46 | 183016 | 1364 | 994896 | 33 | 188120 | 1396 | 811880 | 14 |
| 47 | 183834 | 1361 | 994877 | 33 | 188958 | 1393 | 811042 | 13 |
| 48 | 184651 | 1359 | 994857 | 33 | 189794 | 1391 | 810206 | 12 |
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| 50 | 186280 | 1353 | 994818 | 33 | 191462 | 1386 | 808538 | 10 |
| 51 | 9·187092 | 1351 | 9·994798 | 33 | 9·192294 | 1384 | 10·807706 | 9 |
| 52 | 187903 | 1348 | 994779 | 33 | 193124 | 1381 | 806876 | 8 |
| 53 | 188712 | 1346 | 994759 | 33 | 193953 | 1379 | 806047 | 7 |
| 54 | 189519 | 1343 | 994739 | 33 | 194780 | 1376 | 805220 | 6 |
| 55 | 190325 | 1341 | 994719 | 33 | 195606 | 1374 | 804394 | 5 |
| 56 | 191130 | 1338 | 994700 | 33 | 196430 | 1371 | 803570 | 4 |
| 57 | 191933 | 1336 | 994680 | 33 | 197253 | 1369 | 802747 | 3 |
| 58 | 192734 | 1333 | 994660 | 33 | 198074 | 1366 | 801926 | 2 |
| 59 | 193534 | 1330 | 994640 | 33 | 198894 | 1364 | 801106 | 1 |
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| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·194332 | 1328 | 9·994930 | 33 | 9 199713 | 1361 | 10·800287 | 60 |
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| 2 | 195925 | 1323 | 994580 | 33 | 201345 | 1356 | 798655 | 58 |
| 3 | 196719 | 1321 | 994560 | 34 | 202159 | 1354 | 797841 | 57 |
| 4 | 197511 | 1318 | 994540 | 34 | 202971 | 1352 | 797029 | 56 |
| 5 | 198302 | 1316 | 994519 | 34 | 203782 | 1349 | 796218 | 55 |
| 6 | 199091 | 1313 | 994499 | 34 | 204592 | 1347 | 795408 | 54 |
| 7 | 199879 | 1311 | 994479 | 34 | 205400 | 1345 | 794600 | 53 |
| 8 | 200666 | 1308 | 994459 | 34 | 206207 | 1342 | 793793 | 52 |
| 9 | 201451 | 1306 | 994438 | 34 | 207013 | 1340 | 792987 | 51 |
| 10 | 202234 | 1304 | 994418 | 34 | 207817 | 1338 | 792183 | 50 |
| 11 | 9·203017 | 1301 | 9·994397 | 34 | 9·208619 | 1335 | 10·791381 | 49 |
| 12 | 203797 | 1299 | 994377 | 34 | 209420 | 1333 | 790580 | 48 |
| 13 | 204577 | 1296 | 994357 | 34 | 210220 | 1331 | 789780 | 47 |
| 14 | 205354 | 1294 | 994336 | 34 | 211018 | 1328 | 788982 | 46 |
| 15 | 206131 | 1292 | 994316 | 34 | 211815 | 1326 | 788185 | 45 |
| 16 | 206906 | 1289 | 994295 | 34 | 212611 | 1324 | 787389 | 44 |
| 17 | 207679 | 1287 | 994274 | 35 | 213405 | 1321 | 786595 | 43 |
| 18 | 208452 | 1285 | 994254 | 35 | 214198 | 1319 | 785802 | 42 |
| 19 | 209222 | 1282 | 994233 | 35 | 214989 | 1317 | 785011 | 41 |
| 20 | 209992 | 1280 | 994212 | 35 | 215780 | 1315 | 784220 | 40 |
| 21 | 9·210760 | 1278 | 9·994191 | 35 | 9·216568 | 1312 | 10·783432 | 39 |
| 22 | 211526 | 1275 | 994171 | 35 | 217356 | 1310 | 782644 | 38 |
| 23 | 212291 | 1273 | 994150 | 35 | 218142 | 1308 | 781858 | 37 |
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| 26 | 214579 | 1266 | 994087 | 35 | 220492 | 1301 | 779508 | 34 |
| 27 | 215338 | 1264 | 994066 | 35 | 221272 | 1299 | 778728 | 33 |
| 28 | 216097 | 1261 | 994045 | 35 | 222052 | 1297 | 777948 | 32 |
| 29 | 216854 | 1259 | 994024 | 35 | 222830 | 1294 | 777170 | 31 |
| 30 | 217609 | 1257 | 994003 | 35 | 223606 | 1292 | 776394 | 30 |
| 31 | 9·218363 | 1255 | 9·993981 | 35 | 9·224382 | 1290 | 10·775618 | 29 |
| 32 | 219116 | 1253 | 993960 | 35 | 225156 | 1288 | 774844 | 28 |
| 33 | 219868 | 1250 | 993939 | 35 | 225929 | 1286 | 774071 | 27 |
| 34 | 220618 | 1248 | 993918 | 35 | 226700 | 1284 | 773300 | 26 |
| 35 | 221367 | 1246 | 993896 | 36 | 227471 | 1281 | 772529 | 25 |
| 36 | 222115 | 1244 | 993875 | 36 | 228239 | 1279 | 771761 | 24 |
| 37 | 222861 | 1242 | 993854 | 36 | 229007 | 1277 | 770993 | 23 |
| 38 | 223606 | 1239 | 993832 | 36 | 229773 | 1275 | 770227 | 22 |
| 39 | 224349 | 1237 | 993811 | 36 | 230539 | 1273 | 769461 | 21 |
| 40 | 225092 | 1235 | 993789 | 36 | 231302 | 1271 | 768698 | 20 |
| 41 | 9·225833 | 1233 | 9·993768 | 36 | 9·232065 | 1269 | 10·767935 | 19 |
| 42 | 226573 | 1231 | 993746 | 36 | 232826 | 1267 | 767174 | 18 |
| 43 | 227311 | 1228 | 993725 | 36 | 233586 | 1265 | 766414 | 17 |
| 44 | 228048 | 1226 | 993703 | 36 | 234345 | 1262 | 765655 | 16 |
| 45 | 228784 | 1224 | 993681 | 36 | 235103 | 1260 | 764897 | 15 |
| 46 | 229518 | 1222 | 993660 | 36 | 235859 | 1258 | 764141 | 14 |
| 47 | 230252 | 1220 | 993638 | 36 | 236614 | 1256 | 763386 | 13 |
| 48 | 230984 | 1218 | 993616 | 36 | 237368 | 1254 | 762632 | 12 |
| 49 | 231714 | 1216 | 993594 | 37 | 238120 | 1252 | 761880 | 11 |
| 50 | 232444 | 1214 | 993572 | 37 | 238872 | 1250 | 761128 | 10 |
| 51 | 9·233172 | 1212 | 9·993550 | 37 | 9·239622 | 1248 | 10·760378 | 9 |
| 52 | 233899 | 1209 | 993528 | 37 | 240371 | 1246 | 759629 | 8 |
| 53 | 234625 | 1207 | 993506 | 37 | 241118 | 1244 | 758882 | 7 |
| 54 | 235349 | 1205 | 993484 | 37 | 241865 | 1242 | 758135 | 6 |
| 55 | 236073 | 1203 | 993462 | 37 | 242610 | 1240 | 757390 | 5 |
| 56 | 236795 | 1201 | 993440 | 37 | 243354 | 1238 | 756646 | 4 |
| 57 | 237515 | 1199 | 993418 | 37 | 244097 | 1236 | 755903 | 3 |
| 58 | 238235 | 1197 | 993396 | 37 | 244839 | 1234 | 755161 | 2 |
| 59 | 238953 | 1195 | 993374 | 37 | 245579 | 1232 | 754421 | 1 |
| 60 | 239670 | 1193 | 993351 | 37 | 246319 | 1230 | 753681 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·239670 | 1193 | 9·993351 | 37 | 9·246319 | 1230 | 10·753681 | 60 |
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| 2 | 241101 | 1189 | 993307 | 37 | 247794 | 1226 | 752206 | 58 |
| 3 | 241814 | 1187 | 993285 | 37 | 248530 | 1224 | 751470 | 57 |
| 4 | 242526 | 1185 | 993262 | 37 | 249264 | 1222 | 750736 | 56 |
| 5 | 243237 | 1183 | 993240 | 37 | 249998 | 1220 | 750002 | 55 |
| 6 | 243947 | 1181 | 993217 | 38 | 250730 | 1218 | 749270 | 54 |
| 7 | 244656 | 1179 | 993195 | 38 | 251461 | 1217 | 748539 | 53 |
| 8 | 245363 | 1177 | 993172 | 38 | 252191 | 1215 | 747809 | 52 |
| 9 | 246069 | 1175 | 993149 | 38 | 252920 | 1213 | 747080 | 51 |
| 10 | 246775 | 1173 | 993127 | 38 | 253648 | 1211 | 746352 | 50 |
| 11 | 9·247478 | 1171 | 9·993104 | 38 | 9·254374 | 1209 | 10·745626 | 49 |
| 12 | 248181 | 1169 | 993081 | 38 | 255100 | 1207 | 744900 | 48 |
| 13 | 248883 | 1167 | 993059 | 38 | 255824 | 1205 | 744176 | 47 |
| 14 | 249583 | 1165 | 993036 | 38 | 256547 | 1203 | 743453 | 46 |
| 15 | 250282 | 1163 | 993013 | 38 | 257269 | 1201 | 742731 | 45 |
| 16 | 250980 | 1161 | 992990 | 38 | 257990 | 1200 | 742010 | 44 |
| 17 | 251677 | 1159 | 992967 | 38 | 258710 | 1198 | 741290 | 43 |
| 18 | 252373 | 1158 | 992944 | 38 | 259429 | 1196 | 740571 | 42 |
| 19 | 253067 | 1156 | 992921 | 38 | 260146 | 1194 | 739854 | 41 |
| 20 | 253761 | 1154 | 992898 | 38 | 260863 | 1192 | 739137 | 40 |
| 21 | 9·254453 | 1152 | 9·992875 | 38 | 9·261578 | 1190 | 10·738422 | 39 |
| 22 | 255144 | 1150 | 992852 | 38 | 262292 | 1189 | 737708 | 38 |
| 23 | 255834 | 1148 | 992829 | 39 | 263005 | 1187 | 736995 | 37 |
| 24 | 256523 | 1146 | 992806 | 39 | 263717 | 1185 | 736283 | 36 |
| 25 | 257211 | 1144 | 992783 | 39 | 264428 | 1183 | 735572 | 35 |
| 26 | 257898 | 1142 | 992759 | 39 | 265138 | 1181 | 734862 | 34 |
| 27 | 258583 | 1141 | 992736 | 39 | 265847 | 1179 | 734153 | 33 |
| 28 | 259268 | 1139 | 992713 | 39 | 266555 | 1178 | 733445 | 32 |
| 29 | 259951 | 1137 | 992690 | 39 | 267261 | 1176 | 732739 | 31 |
| 30 | 260633 | 1135 | 992666 | 39 | 267967 | 1174 | 732033 | 30 |
| 31 | 9·261314 | 1133 | 9·992643 | 39 | 9·268671 | 1172 | 10·731329 | 29 |
| 32 | 261994 | 1131 | 992619 | 39 | 269375 | 1170 | 730625 | 28 |
| 33 | 262673 | 1130 | 992596 | 39 | 270077 | 1169 | 729923 | 27 |
| 34 | 263351 | 1128 | 992572 | 39 | 270779 | 1167 | 729221 | 26 |
| 35 | 264027 | 1126 | 992549 | 39 | 271479 | 1165 | 728521 | 25 |
| 36 | 264703 | 1124 | 992525 | 39 | 272178 | 1164 | 727822 | 24 |
| 37 | 265377 | 1122 | 992501 | 39 | 272876 | 1162 | 727124 | 23 |
| 38 | 266051 | 1120 | 992478 | 40 | 273573 | 1160 | 726427 | 22 |
| 39 | 266723 | 1119 | 992454 | 40 | 274269 | 1158 | 725731 | 21 |
| 40 | 267395 | 1117 | 992430 | 40 | 274964 | 1157 | 725036 | 20 |
| 41 | 9·268065 | 1115 | 9·992406 | 40 | 9·275658 | 1155 | 10·724342 | 19 |
| 42 | 268734 | 1113 | 992382 | 40 | 276351 | 1153 | 723649 | 18 |
| 43 | 269402 | 1111 | 992359 | 40 | 277043 | 1151 | 722957 | 17 |
| 44 | 270069 | 1110 | 992335 | 40 | 277734 | 1150 | 722266 | 16 |
| 45 | 270735 | 1108 | 992311 | 40 | 278424 | 1148 | 721576 | 15 |
| 46 | 271400 | 1106 | 992287 | 40 | 279113 | 1147 | 720887 | 14 |
| 47 | 272064 | 1105 | 992263 | 40 | 279801 | 1145 | 720199 | 13 |
| 48 | 272726 | 1103 | 992239 | 40 | 280488 | 1143 | 719512 | 12 |
| 49 | 273388 | 1101 | 992214 | 40 | 281174 | 1141 | 718826 | 11 |
| 50 | 274049 | 1199 | 992190 | 40 | 281858 | 1140 | 718142 | 10 |
| 51 | 9·274708 | 1098 | 9·992166 | 40 | 9·282542 | 1138 | 10·717458 | 9 |
| 52 | 275367 | 1096 | 992142 | 40 | 283225 | 1136 | 716775 | 8 |
| 53 | 276024 | 1094 | 992117 | 41 | 283907 | 1135 | 716093 | 7 |
| 54 | 276681 | 1092 | 992093 | 41 | 284588 | 1133 | 715412 | 6 |
| 55 | 277337 | 1091 | 992069 | 41 | 285268 | 1131 | 714732 | 5 |
| 56 | 277991 | 1089 | 992044 | 41 | 285947 | 1130 | 714053 | 4 |
| 57 | 278644 | 1087 | 992020 | 41 | 286624 | 1128 | 713376 | 3 |
| 58 | 279297 | 1086 | 991996 | 41 | 287301 | 1126 | 712699 | 2 |
| 59 | 279948 | 1084 | 991971 | 41 | 287977 | 1125 | 712023 | 1 |
| 60 | 280599 | 1082 | 991947 | 41 | 288652 | 1123 | 711348 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·280590 | 1082 | 9·991947 | 41 | 9·288652 | 1123 | 10·711348 | 60 |
| 1 | 281248 | 1081 | 991922 | 41 | 289326 | 1122 | 710674 | 59 |
| 2 | 281897 | 1079 | 991897 | 41 | 289999 | 1120 | 710001 | 58 |
| 3 | 282544 | 1077 | 991873 | 41 | 290671 | 1118 | 709329 | 57 |
| 4 | 283190 | 1076 | 991848 | 41 | 291342 | 1117 | 708658 | 56 |
| 5 | 283836 | 1074 | 991823 | 41 | 292013 | 1115 | 707987 | 55 |
| 6 | 284480 | 1072 | 991799 | 41 | 292682 | 1114 | 707318 | 54 |
| 7 | 285124 | 1071 | 991774 | 42 | 293350 | 1112 | 706650 | 53 |
| 8 | 285766 | 1069 | 991749 | 42 | 294017 | 1111 | 705983 | 52 |
| 9 | 286408 | 1067 | 991724 | 42 | 294684 | 1109 | 705316 | 51 |
| 10 | 287048 | 1066 | 991699 | 42 | 295349 | 1107 | 704651 | 50 |
| 11 | 9·287687 | 1064 | 9·991674 | 42 | 9·296013 | 1106 | 10·703987 | 49 |
| 12 | 288326 | 1063 | 991649 | 42 | 296677 | 1104 | 703323 | 48 |
| 13 | 288964 | 1061 | 991624 | 42 | 297339 | 1103 | 702661 | 47 |
| 14 | 289600 | 1059 | 991599 | 42 | 298001 | 1101 | 701999 | 46 |
| 15 | 290236 | 1058 | 991574 | 42 | 298662 | 1100 | 701338 | 45 |
| 16 | 290870 | 1056 | 991549 | 42 | 299322 | 1098 | 700678 | 44 |
| 17 | 291504 | 1054 | 991524 | 42 | 299980 | 1096 | 700020 | 43 |
| 18 | 292137 | 1053 | 991498 | 42 | 300638 | 1095 | 699362 | 42 |
| 19 | 292768 | 1051 | 991473 | 42 | 301295 | 1093 | 698705 | 41 |
| 20 | 293399 | 1050 | 991448 | 42 | 301951 | 1092 | 698049 | 40 |
| 21 | 9·294029 | 1048 | 9·991422 | 42 | 9·302607 | 1090 | 10·697393 | 39 |
| 22 | 294658 | 1046 | 991397 | 42 | 303261 | 1089 | 696739 | 38 |
| 23 | 295286 | 1045 | 991372 | 43 | 303914 | 1087 | 696086 | 37 |
| 24 | 295913 | 1043 | 991346 | 43 | 304567 | 1086 | 695433 | 36 |
| 25 | 296539 | 1042 | 991321 | 43 | 305218 | 1084 | 694782 | 35 |
| 26 | 297164 | 1040 | 991295 | 43 | 305869 | 1083 | 694131 | 34 |
| 27 | 297788 | 1039 | 991270 | 43 | 306519 | 1081 | 693481 | 33 |
| 28 | 298412 | 1037 | 991244 | 43 | 307168 | 1080 | 692832 | 32 |
| 29 | 299034 | 1036 | 991218 | 43 | 307815 | 1078 | 692185 | 31 |
| 30 | 299655 | 1034 | 991193 | 43 | 308463 | 1077 | 691537 | 30 |
| 31 | 9·300276 | 1032 | 9·991167 | 43 | 9·309109 | 1075 | 10·690891 | 29 |
| 32 | 300895 | 1031 | 991141 | 43 | 309754 | 1074 | 690246 | 28 |
| 33 | 301514 | 1029 | 991115 | 43 | 310398 | 1073 | 689602 | 27 |
| 34 | 302132 | 1028 | 991090 | 43 | 311042 | 1071 | 688958 | 26 |
| 35 | 302748 | 1026 | 991064 | 43 | 311685 | 1070 | 688315 | 25 |
| 36 | 303364 | 1025 | 991038 | 43 | 312327 | 1068 | 687673 | 24 |
| 37 | 303979 | 1023 | 991012 | 43 | 312967 | 1067 | 687033 | 23 |
| 38 | 304593 | 1022 | 990986 | 43 | 313608 | 1065 | 686392 | 22 |
| 39 | 305207 | 1020 | 990960 | 43 | 314247 | 1064 | 685753 | 21 |
| 40 | 305819 | 1019 | 990934 | 44 | 314885 | 1062 | 685115 | 20 |
| 41 | 9·306430 | 1017 | 9·990908 | 44 | 9·315523 | 1061 | 10·684477 | 19 |
| 42 | 307041 | 1016 | 990882 | 44 | 316159 | 1060 | 683841 | 18 |
| 43 | 307650 | 1014 | 990855 | 44 | 316795 | 1058 | 683205 | 17 |
| 44 | 308259 | 1013 | 990829 | 44 | 317430 | 1057 | 682570 | 16 |
| 45 | 308867 | 1011 | 990803 | 44 | 318064 | 1055 | 681936 | 15 |
| 46 | 309474 | 1010 | 990777 | 44 | 318697 | 1054 | 681303 | 14 |
| 47 | 310080 | 1008 | 990750 | 44 | 319329 | 1053 | 680671 | 13 |
| 48 | 310685 | 1007 | 990724 | 44 | 319961 | 1051 | 680039 | 12 |
| 49 | 311289 | 1005 | 990697 | 44 | 320592 | 1050 | 679408 | 11 |
| 50 | 311893 | 1004 | 990671 | 44 | 321222 | 1048 | 678778 | 10 |
| 51 | 9·312495 | 1003 | 9·990644 | 44 | 9·321851 | 1047 | 10·678149 | 9 |
| 52 | 313097 | 1001 | 990618 | 44 | 322479 | 1045 | 677521 | 8 |
| 53 | 313698 | 1000 | 990591 | 44 | 323106 | 1044 | 676894 | 7 |
| 54 | 314297 | 998 | 990565 | 44 | 323733 | 1043 | 676267 | 6 |
| 55 | 314897 | 997 | 990538 | 44 | 324358 | 1041 | 675642 | 5 |
| 56 | 315495 | 996 | 990511 | 45 | 324983 | 1040 | 675017 | 4 |
| 57 | 316092 | 994 | 990485 | 45 | 325607 | 1039 | 674393 | 3 |
| 58 | 316689 | 993 | 990458 | 45 | 326231 | 1037 | 673769 | 2 |
| 59 | 317284 | 991 | 990431 | 45 | 326853 | 1036 | 673147 | 1 |
| 60 | 317879 | 990 | 990404 | 45 | 327475 | 1035 | 672525 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·317879 | 990 | 9·990404 | 45 | 9·327474 | 1035 | 10·672526 | 60 |
| 1 | 318473 | 988 | 990378 | 45 | 328095 | 1033 | 671905 | 59 |
| 2 | 319066 | 987 | 990351 | 45 | 328715 | 1032 | 671285 | 58 |
| 3 | 319658 | 986 | 990324 | 45 | 329334 | 1030 | 670666 | 57 |
| 4 | 320249 | 984 | 990297 | 45 | 329953 | 1029 | 670047 | 56 |
| 5 | 320840 | 983 | 990270 | 45 | 330570 | 1028 | 669430 | 55 |
| 6 | 321430 | 982 | 990243 | 45 | 331187 | 1026 | 668813 | 54 |
| 7 | 322019 | 980 | 990215 | 45 | 331803 | 1025 | 668197 | 53 |
| 8 | 322607 | 979 | 990188 | 45 | 332418 | 1024 | 667582 | 52 |
| 9 | 323194 | 977 | 990161 | 45 | 333033 | 1023 | 666967 | 51 |
| 10 | 323780 | 976 | 990134 | 45 | 333646 | 1021 | 666354 | 50 |
| 11 | 9·324366 | 975 | 9·990107 | 46 | 9·334259 | 1020 | 10·665741 | 49 |
| 12 | 324950 | 973 | 990079 | 46 | 334871 | 1019 | 665129 | 48 |
| 13 | 325534 | 972 | 990052 | 46 | 335482 | 1017 | 664518 | 47 |
| 14 | 326117 | 970 | 990025 | 46 | 336093 | 1016 | 663907 | 46 |
| 15 | 326700 | 969 | 989997 | 46 | 336702 | 1015 | 663298 | 45 |
| 16 | 327281 | 968 | 989970 | 46 | 337311 | 1013 | 662689 | 44 |
| 17 | 327862 | 966 | 989942 | 46 | 337919 | 1012 | 662081 | 43 |
| 18 | 328442 | 965 | 989915 | 46 | 338527 | 1011 | 661473 | 42 |
| 19 | 329021 | 964 | 989887 | 46 | 339133 | 1010 | 660867 | 41 |
| 20 | 329599 | 962 | 989860 | 46 | 339739 | 1008 | 660261 | 40 |
| 21 | 9·330176 | 961 | 9·989832 | 46 | 9·340344 | 1007 | 10·659656 | 39 |
| 22 | 330753 | 960 | 989804 | 46 | 340948 | 1006 | 659052 | 38 |
| 23 | 331329 | 958 | 989777 | 46 | 341552 | 1004 | 658448 | 37 |
| 24 | 331903 | 957 | 989749 | 47 | 342155 | 1003 | 657845 | 36 |
| 25 | 332478 | 956 | 989721 | 47 | 342757 | 1002 | 657243 | 35 |
| 26 | 333051 | 954 | 989693 | 47 | 343358 | 1000 | 656642 | 34 |
| 27 | 333624 | 953 | 989665 | 47 | 343958 | 999 | 656042 | 33 |
| 28 | 334195 | 952 | 989637 | 47 | 344558 | 998 | 655442 | 32 |
| 29 | 334766 | 950 | 989609 | 47 | 345157 | 997 | 654843 | 31 |
| 30 | 335337 | 949 | 989582 | 47 | 345755 | 996 | 654245 | 30 |
| 31 | 9·335906 | 948 | 9·989553 | 47 | 9·346353 | 994 | 10·653647 | 29 |
| 32 | 336475 | 946 | 989525 | 47 | 346949 | 993 | 653051 | 28 |
| 33 | 337043 | 945 | 989497 | 47 | 347545 | 992 | 652455 | 27 |
| 34 | 337610 | 944 | 989469 | 47 | 348141 | 991 | 651859 | 26 |
| 35 | 338176 | 943 | 989441 | 47 | 348735 | 990 | 651265 | 25 |
| 36 | 338742 | 941 | 989413 | 47 | 349329 | 988 | 650671 | 24 |
| 37 | 339306 | 940 | 989384 | 47 | 349922 | 987 | 650078 | 23 |
| 38 | 339871 | 939 | 989356 | 47 | 350514 | 986 | 649486 | 22 |
| 39 | 340434 | 937 | 989328 | 47 | 351106 | 985 | 648894 | 21 |
| 40 | 340996 | 936 | 989300 | 47 | 351697 | 983 | 648303 | 20 |
| 41 | 9·341558 | 935 | 9·989271 | 47 | 9·352287 | 982 | 10·647713 | 19 |
| 42 | 342119 | 934 | 989243 | 47 | 352876 | 981 | 647124 | 18 |
| 43 | 342679 | 932 | 989214 | 47 | 353465 | 980 | 646535 | 17 |
| 44 | 343239 | 931 | 989186 | 47 | 354053 | 979 | 645947 | 16 |
| 45 | 343797 | 930 | 989157 | 47 | 354640 | 977 | 645360 | 15 |
| 46 | 344355 | 929 | 989128 | 48 | 355227 | 976 | 644773 | 14 |
| 47 | 344912 | 927 | 989100 | 48 | 355813 | 975 | 644187 | 13 |
| 48 | 345469 | 926 | 989071 | 48 | 356398 | 974 | 643602 | 12 |
| 49 | 346024 | 925 | 989042 | 48 | 356982 | 973 | 643018 | 11 |
| 50 | 346579 | 924 | 989014 | 48 | 357566 | 971 | 642434 | 10 |
| 51 | 9·347134 | 922 | 9·988985 | 48 | 9·358149 | 970 | 10·641851 | 9 |
| 52 | 347687 | 921 | 988956 | 48 | 358731 | 969 | 641269 | 8 |
| 53 | 348240 | 920 | 988927 | 48 | 359313 | 968 | 640687 | 7 |
| 54 | 348792 | 919 | 988898 | 48 | 359893 | 967 | 640107 | 6 |
| 55 | 349343 | 917 | 988869 | 48 | 360474 | 966 | 639526 | 5 |
| 56 | 349893 | 916 | 988840 | 48 | 361053 | 965 | 638947 | 4 |
| 57 | 350443 | 915 | 988811 | 49 | 361632 | 963 | 638368 | 3 |
| 58 | 350992 | 914 | 988782 | 49 | 362210 | 962 | 637790 | 2 |
| 59 | 351540 | 913 | 988753 | 49 | 362787 | 961 | 637213 | 1 |
| 60 | 352088 | 911 | 988724 | 49 | 363364 | 960 | 636636 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 2 | 353181 | 909 | 988666 | 49 | 364515 | 958 | 635485 | 58 |
| 3 | 353726 | 908 | 988636 | 49 | 365090 | 957 | 634910 | 57 |
| 4 | 354271 | 907 | 988607 | 49 | 365664 | 955 | 634336 | 56 |
| 5 | 354815 | 905 | 988578 | 49 | 366237 | 954 | 633763 | 55 |
| 6 | 355358 | 904 | 988548 | 49 | 366810 | 953 | 633190 | 54 |
| 7 | 355901 | 903 | 988519 | 49 | 367382 | 952 | 632618 | 53 |
| 8 | 356443 | 902 | 988489 | 49 | 367953 | 951 | 632047 | 52 |
| 9 | 356984 | 901 | 988460 | 49 | 368524 | 950 | 631476 | 51 |
| 10 | 357524 | 899 | 988430 | 49 | 369094 | 949 | 630906 | 50 |
| 11 | 9·358064 | 898 | 9·988401 | 49 | 9·369663 | 948 | 10·630337 | 49 |
| 12 | 358603 | 897 | 988371 | 49 | 370232 | 946 | 629768 | 48 |
| 13 | 359141 | 896 | 988342 | 49 | 370799 | 945 | 629201 | 47 |
| 14 | 359678 | 895 | 988312 | 50 | 371367 | 944 | 628633 | 46 |
| 15 | 360215 | 893 | 988282 | 50 | 371933 | 943 | 628067 | 45 |
| 16 | 360752 | 892 | 988252 | 50 | 372499 | 942 | 627501 | 44 |
| 17 | 361287 | 891 | 988223 | 50 | 373064 | 941 | 626936 | 43 |
| 18 | 361822 | 890 | 988193 | 50 | 373629 | 940 | 626371 | 42 |
| 19 | 362356 | 889 | 988163 | 50 | 374193 | 939 | 625807 | 41 |
| 20 | 362889 | 888 | 988133 | 50 | 374756 | 938 | 625244 | 40 |
| 21 | 9·363422 | 887 | 9·988103 | 50 | 9·375319 | 937 | 10·624681 | 39 |
| 22 | 363954 | 885 | 988073 | 50 | 375881 | 935 | 624119 | 38 |
| 23 | 364485 | 884 | 988043 | 50 | 376442 | 934 | 623558 | 37 |
| 24 | 365016 | 883 | 988013 | 50 | 377003 | 933 | 622997 | 36 |
| 25 | 365546 | 882 | 987983 | 50 | 377563 | 932 | 622437 | 35 |
| 26 | 366075 | 881 | 987953 | 50 | 378122 | 931 | 621878 | 34 |
| 27 | 366604 | 880 | 987922 | 50 | 378681 | 930 | 621319 | 33 |
| 28 | 367131 | 879 | 987892 | 50 | 379239 | 929 | 620761 | 32 |
| 29 | 367659 | 877 | 987862 | 50 | 379797 | 928 | 620203 | 31 |
| 30 | 368185 | 876 | 987832 | 51 | 380354 | 927 | 619646 | 30 |
| 31 | 9·368711 | 875 | 9·987801 | 51 | 9·380910 | 926 | 10·619090 | 29 |
| 32 | 369236 | 874 | 987771 | 51 | 381466 | 925 | 618534 | 28 |
| 33 | 369761 | 873 | 987740 | 51 | 382020 | 924 | 617980 | 27 |
| 34 | 370285 | 872 | 987710 | 51 | 382575 | 923 | 617425 | 26 |
| 35 | 370808 | 871 | 987679 | 51 | 383129 | 922 | 616871 | 25 |
| 36 | 371330 | 870 | 987649 | 51 | 383682 | 921 | 616318 | 24 |
| 37 | 371852 | 869 | 987618 | 51 | 384234 | 920 | 615766 | 23 |
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| 39 | 372894 | 866 | 987557 | 51 | 385337 | 918 | 614663 | 21 |
| 40 | 373414 | 865 | 987526 | 51 | 385888 | 917 | 614112 | 20 |
| 41 | 9·373933 | 864 | 9·987496 | 51 | 9·386438 | 915 | 10·613562 | 19 |
| 42 | 374452 | 863 | 987465 | 51 | 386987 | 914 | 613013 | 18 |
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| 45 | 376003 | 860 | 987372 | 52 | 388631 | 911 | 611369 | 15 |
| 46 | 376519 | 859 | 987341 | 52 | 389178 | 910 | 610822 | 14 |
| 47 | 377035 | 858 | 987310 | 52 | 389724 | 909 | 610276 | 13 |
| 48 | 377549 | 857 | 987279 | 52 | 390270 | 908 | 609730 | 12 |
| 49 | 378063 | 856 | 987248 | 52 | 390815 | 907 | 609185 | 11 |
| 50 | 378577 | 854 | 987217 | 52 | 391360 | 906 | 608640 | 10 |
| 51 | 9·379089 | 853 | 9·987186 | 52 | 9·391903 | 905 | 10·608097 | 9 |
| 52 | 379601 | 852 | 987155 | 52 | 392447 | 904 | 607553 | 8 |
| 53 | 380113 | 851 | 987124 | 52 | 392989 | 903 | 607011 | 7 |
| 54 | 380624 | 850 | 987092 | 52 | 393531 | 902 | 606469 | 6 |
| 55 | 381134 | 849 | 987061 | 52 | 394073 | 901 | 605927 | 5 |
| 56 | 381643 | 848 | 987030 | 52 | 394614 | 900 | 605386 | 4 |
| 57 | 382152 | 847 | 986998 | 52 | 395154 | 899 | 604846 | 3 |
| 58 | 382661 | 846 | 986967 | 52 | 395694 | 898 | 604306 | 2 |
| 59 | 383168 | 845 | 986936 | 52 | 396233 | 897 | 603767 | 1 |
| 60 | 383675 | 844 | 986904 | 52 | 396771 | 896 | 603229 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·383675 | 844 | 9·986904 | 52 | 9·396771 | 896 | 10·603229 | 60 |
| 1 | 384182 | 843 | 986873 | 53 | 397309 | 896 | 602691 | 59 |
| 2 | 384687 | 842 | 986841 | 53 | 397846 | 895 | 602154 | 58 |
| 3 | 385192 | 841 | 986809 | 53 | 398383 | 894 | 601617 | 57 |
| 4 | 385697 | 840 | 986778 | 53 | 398919 | 893 | 601081 | 56 |
| 5 | 386201 | 839 | 986746 | 53 | 399455 | 892 | 600545 | 55 |
| 6 | 386704 | 838 | 986714 | 53 | 399990 | 891 | 600010 | 54 |
| 7 | 387207 | 837 | 986683 | 53 | 400524 | 890 | 599476 | 53 |
| 8 | 387709 | 836 | 986651 | 53 | 401058 | 889 | 598942 | 52 |
| 9 | 388210 | 835 | 986619 | 53 | 401591 | 888 | 598409 | 51 |
| 10 | 388711 | 834 | 986587 | 53 | 402124 | 887 | 597876 | 50 |
| 11 | 9·389211 | 833 | 9·986555 | 53 | 9·402656 | 886 | 10·597344 | 49 |
| 12 | 389711 | 832 | 986523 | 53 | 403187 | 885 | 596813 | 48 |
| 13 | 390210 | 831 | 986491 | 53 | 403718 | 884 | 596282 | 47 |
| 14 | 390708 | 830 | 986459 | 53 | 404249 | 883 | 595751 | 46 |
| 15 | 391206 | 828 | 986427 | 53 | 404778 | 882 | 595222 | 45 |
| 16 | 391703 | 827 | 986395 | 53 | 405308 | 881 | 594692 | 44 |
| 17 | 392199 | 826 | 986363 | 54 | 405836 | 880 | 594164 | 43 |
| 18 | 392695 | 825 | 986331 | 54 | 406364 | 879 | 593636 | 42 |
| 19 | 393191 | 824 | 986299 | 54 | 406892 | 878 | 593108 | 41 |
| 20 | 393685 | 823 | 986266 | 54 | 407419 | 877 | 592581 | 40 |
| 21 | 9·394179 | 822 | 9·986234 | 54 | 9·407945 | 876 | 10·592055 | 39 |
| 22 | 394673 | 821 | 986202 | 54 | 408471 | 875 | 591529 | 38 |
| 23 | 395166 | 820 | 986169 | 54 | 408997 | 874 | 591003 | 37 |
| 24 | 395658 | 819 | 986137 | 54 | 409521 | 874 | 590479 | 36 |
| 25 | 396150 | 818 | 986104 | 54 | 410045 | 873 | 589955 | 35 |
| 26 | 396641 | 817 | 986072 | 54 | 410569 | 872 | 589431 | 34 |
| 27 | 397132 | 817 | 986039 | 54 | 411092 | 871 | 588908 | 33 |
| 28 | 397621 | 816 | 986007 | 54 | 411615 | 870 | 588385 | 32 |
| 29 | 398111 | 815 | 985974 | 54 | 412137 | 869 | 587863 | 31 |
| 30 | 398600 | 814 | 985942 | 54 | 412658 | 868 | 587342 | 30 |
| 31 | 9·399088 | 813 | 9·985909 | 55 | 9·413179 | 867 | 10·586821 | 29 |
| 32 | 399575 | 812 | 985876 | 55 | 413699 | 866 | 586301 | 28 |
| 33 | 400062 | 811 | 985843 | 55 | 414219 | 865 | 585781 | 27 |
| 34 | 400549 | 810 | 985811 | 55 | 414738 | 864 | 585262 | 26 |
| 35 | 401035 | 809 | 985778 | 55 | 415257 | 864 | 584743 | 25 |
| 36 | 401520 | 808 | 985745 | 55 | 415775 | 863 | 584225 | 24 |
| 37 | 402005 | 807 | 985712 | 55 | 416293 | 862 | 583707 | 23 |
| 38 | 402489 | 806 | 985679 | 55 | 416810 | 861 | 583190 | 22 |
| 39 | 402972 | 805 | 985646 | 55 | 417326 | 860 | 582674 | 21 |
| 40 | 403455 | 804 | 985613 | 55 | 417842 | 859 | 582158 | 20 |
| 41 | 9·403938 | 803 | 9·985580 | 55 | 9·418358 | 858 | 10·581642 | 19 |
| 42 | 404420 | 802 | 985547 | 55 | 418873 | 857 | 581127 | 18 |
| 43 | 404901 | 801 | 985514 | 55 | 419387 | 856 | 580613 | 17 |
| 44 | 405382 | 800 | 985480 | 55 | 419901 | 855 | 580099 | 16 |
| 45 | 405862 | 799 | 985447 | 55 | 420415 | 855 | 579585 | 15 |
| 46 | 406341 | 798 | 985414 | 56 | 420927 | 854 | 579073 | 14 |
| 47 | 406820 | 797 | 985380 | 56 | 421440 | 853 | 578560 | 13 |
| 48 | 407299 | 796 | 985347 | 56 | 421952 | 852 | 578048 | 12 |
| 49 | 407777 | 795 | 985314 | 56 | 422463 | 851 | 577537 | 11 |
| 50 | 408254 | 794 | 985280 | 56 | 422974 | 850 | 577026 | 10 |
| 51 | 9·408731 | 794 | 9·985247 | 56 | 9·423484 | 849 | 10·576516 | 9 |
| 52 | 409207 | 793 | 985213 | 56 | 423993 | 848 | 576007 | 8 |
| 53 | 409682 | 792 | 985180 | 56 | 424503 | 848 | 575497 | 7 |
| 54 | 410157 | 791 | 985146 | 56 | 425011 | 847 | 574989 | 6 |
| 55 | 410632 | 790 | 985113 | 56 | 425519 | 846 | 574481 | 5 |
| 56 | 411106 | 789 | 985079 | 56 | 426027 | 845 | 573973 | 4 |
| 57 | 411579 | 788 | 985045 | 56 | 426534 | 844 | 573466 | 3 |
| 58 | 412052 | 787 | 985011 | 56 | 427041 | 843 | 572959 | 2 |
| 59 | 412524 | 786 | 984978 | 56 | 427547 | 843 | 572453 | 1 |
| 60 | 412996 | 765 | 984944 | 56 | 428052 | 842 | 571948 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·412996 | 785 | 9·984944 | 57 | 9·428052 | 842 | 10·571948 | 60 |
| 1 | 413467 | 784 | 984910 | 57 | 428557 | 841 | 571443 | 59 |
| 2 | 413938 | 783 | 984876 | 57 | 429062 | 840 | 570938 | 58 |
| 3 | 414408 | 783 | 984842 | 57 | 429566 | 839 | 570434 | 57 |
| 4 | 414878 | 782 | 984808 | 57 | 430070 | 838 | 569930 | 56 |
| 5 | 415347 | 781 | 984774 | 57 | 430573 | 838 | 569427 | 55 |
| 6 | 415815 | 780 | 984740 | 57 | 431075 | 837 | 568925 | 54 |
| 7 | 416283 | 779 | 984706 | 57 | 431577 | 836 | 568423 | 53 |
| 8 | 416751 | 778 | 984672 | 57 | 432079 | 835 | 567921 | 52 |
| 9 | 417217 | 777 | 984637 | 57 | 432580 | 834 | 567420 | 51 |
| 10 | 417684 | 776 | 984603 | 57 | 433080 | 833 | 566920 | 50 |
| 11 | 9·418150 | 775 | 9·984569 | 57 | 9·433580 | 832 | 10·566420 | 49 |
| 12 | 418615 | 774 | 984535 | 57 | 434080 | 832 | 565920 | 48 |
| 13 | 419079 | 773 | 984500 | 57 | 434579 | 831 | 565421 | 47 |
| 14 | 419544 | 773 | 984466 | 57 | 435078 | 830 | 564922 | 46 |
| 15 | 420007 | 772 | 984432 | 58 | 435576 | 829 | 564424 | 45 |
| 16 | 420470 | 771 | 984397 | 58 | 436073 | 828 | 563927 | 44 |
| 17 | 420933 | 770 | 984363 | 58 | 436570 | 828 | 563430 | 43 |
| 18 | 421395 | 769 | 984328 | 58 | 437067 | 827 | 562933 | 42 |
| 19 | 421857 | 768 | 984294 | 58 | 437563 | 826 | 562437 | 41 |
| 20 | 422318 | 767 | 984259 | 58 | 438059 | 825 | 561941 | 40 |
| 21 | 9·422778 | 767 | 9·984224 | 58 | 9·438554 | 824 | 10·561446 | 39 |
| 22 | 423238 | 766 | 984190 | 58 | 439048 | 823 | 560952 | 38 |
| 23 | 423697 | 765 | 984155 | 58 | 439543 | 823 | 560457 | 37 |
| 24 | 424156 | 764 | 984120 | 58 | 440036 | 822 | 559964 | 36 |
| 25 | 424615 | 763 | 984085 | 58 | 440529 | 821 | 559471 | 35 |
| 26 | 425073 | 762 | 984050 | 58 | 441022 | 820 | 558978 | 34 |
| 27 | 425530 | 761 | 984015 | 58 | 441514 | 819 | 558486 | 33 |
| 28 | 425987 | 760 | 983981 | 58 | 442006 | 819 | 557994 | 32 |
| 29 | 426443 | 760 | 983946 | 58 | 442497 | 818 | 557503 | 31 |
| 30 | 426899 | 759 | 983911 | 58 | 442988 | 817 | 557012 | 30 |
| 31 | 9·427354 | 758 | 9·983875 | 58 | 9·443479 | 816 | 10·556521 | 29 |
| 32 | 427809 | 757 | 983840 | 59 | 443968 | 816 | 556032 | 28 |
| 33 | 428263 | 756 | 983805 | 59 | 444458 | 815 | 555542 | 27 |
| 34 | 428717 | 755 | 983770 | 59 | 444947 | 814 | 555053 | 26 |
| 35 | 429170 | 754 | 983735 | 59 | 445435 | 813 | 554565 | 25 |
| 36 | 429623 | 753 | 983700 | 59 | 445923 | 812 | 554077 | 24 |
| 37 | 430075 | 752 | 983664 | 59 | 446411 | 812 | 553589 | 23 |
| 38 | 430527 | 752 | 983629 | 59 | 446898 | 811 | 553102 | 22 |
| 39 | 430978 | 751 | 983594 | 59 | 447384 | 810 | 552616 | 21 |
| 40 | 431429 | 750 | 983558 | 59 | 447870 | 809 | 552130 | 20 |
| 41 | 9·431879 | 749 | 9·983523 | 59 | 9·448356 | 809 | 10·551644 | 19 |
| 42 | 432329 | 749 | 983487 | 59 | 448841 | 808 | 551159 | 18 |
| 43 | 432778 | 748 | 983452 | 59 | 449326 | 807 | 550674 | 17 |
| 44 | 433226 | 747 | 983416 | 59 | 449810 | 806 | 550190 | 16 |
| 45 | 433675 | 746 | 983381 | 59 | 450294 | 806 | 549706 | 15 |
| 46 | 434122 | 745 | 983345 | 59 | 450777 | 805 | 549223 | 14 |
| 47 | 434569 | 744 | 983309 | 59 | 451260 | 804 | 548740 | 13 |
| 48 | 435016 | 744 | 983273 | 60 | 451743 | 803 | 548257 | 12 |
| 49 | 435462 | 743 | 983238 | 60 | 452225 | 802 | 547775 | 11 |
| 50 | 435908 | 742 | 983202 | 60 | 452706 | 802 | 547294 | 10 |
| 51 | 9·436353 | 741 | 9·983166 | 60 | 9·453187 | 801 | 10·546813 | 9 |
| 52 | 436798 | 740 | 983130 | 60 | 453668 | 800 | 546332 | 8 |
| 53 | 437242 | 740 | 983094 | 60 | 454148 | 799 | 545852 | 7 |
| 54 | 437686 | 739 | 983058 | 60 | 454628 | 799 | 545372 | 6 |
| 55 | 438129 | 738 | 983022 | 60 | 455107 | 798 | 544893 | 5 |
| 56 | 438572 | 737 | 982986 | 60 | 455586 | 797 | 544414 | 4 |
| 57 | 439014 | 736 | 982950 | 60 | 456064 | 796 | 543936 | 3 |
| 58 | 439456 | 736 | 982914 | 60 | 456542 | 796 | 543458 | 2 |
| 59 | 439897 | 735 | 982878 | 60 | 457019 | 795 | 542981 | 1 |
| 60 | 440338 | 734 | 982842 | 60 | 457496 | 794 | 542504 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

74 Degrees.

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·440338 | 734 | 9·982842 | 60 | 9·457496 | 794 | 10·542504 | 60 |
| 1 | 440778 | 733 | 982805 | 60 | 457973 | 793 | 542027 | 59 |
| 2 | 441218 | 732 | 982769 | 61 | 458449 | 793 | 541551 | 58 |
| 3 | 441658 | 731 | 982733 | 61 | 458925 | 792 | 541075 | 57 |
| 4 | 442096 | 731 | 982696 | 61 | 459400 | 791 | 540600 | 56 |
| 5 | 442535 | 730 | 982660 | 61 | 459875 | 790 | 540125 | 55 |
| 6 | 442973 | 729 | 982624 | 61 | 460349 | 790 | 539651 | 54 |
| 7 | 443410 | 728 | 982587 | 61 | 460823 | 789 | 539177 | 53 |
| 8 | 443847 | 727 | 982551 | 61 | 461297 | 788 | 538703 | 52 |
| 9 | 444284 | 727 | 982514 | 61 | 461770 | 788 | 538230 | 51 |
| 10 | 444720 | 726 | 982477 | 61 | 462242 | 787 | 537758 | 50 |
| 11 | 9·445155 | 725 | 9·982441 | 61 | 9·462714 | 786 | 10·537286 | 49 |
| 12 | 445590 | 724 | 982404 | 61 | 463186 | 785 | 536814 | 48 |
| 13 | 446025 | 723 | 982367 | 61 | 463658 | 785 | 536342 | 47 |
| 14 | 446459 | 723 | 982331 | 61 | 464129 | 784 | 535871 | 46 |
| 15 | 446893 | 722 | 982294 | 61 | 464599 | 783 | 535401 | 45 |
| 16 | 447326 | 721 | 982257 | 61 | 465069 | 783 | 534931 | 44 |
| 17 | 447759 | 720 | 982220 | 62 | 465539 | 782 | 534461 | 43 |
| 18 | 448191 | 720 | 982183 | 62 | 466008 | 781 | 533992 | 42 |
| 19 | 448623 | 719 | 982146 | 62 | 466476 | 780 | 533524 | 41 |
| 20 | 449054 | 718 | 982109 | 62 | 466945 | 780 | 533055 | 40 |
| 21 | 9·449485 | 717 | 9·982072 | 62 | 9·467413 | 779 | 10·532587 | 39 |
| 22 | 449915 | 716 | 982035 | 62 | 467880 | 778 | 532120 | 38 |
| 23 | 450345 | 716 | 981998 | 62 | 468347 | 778 | 531653 | 37 |
| 24 | 450775 | 715 | 981961 | 62 | 468814 | 777 | 531186 | 36 |
| 25 | 451204 | 714 | 981924 | 62 | 469280 | 776 | 530720 | 35 |
| 26 | 451632 | 713 | 981886 | 62 | 469746 | 775 | 530254 | 34 |
| 27 | 452060 | 713 | 981849 | 62 | 470211 | 775 | 529789 | 33 |
| 28 | 452488 | 712 | 981812 | 62 | 470676 | 774 | 529324 | 32 |
| 29 | 452915 | 711 | 981774 | 62 | 471141 | 773 | 528859 | 31 |
| 30 | 453342 | 710 | 981737 | 62 | 471605 | 773 | 528395 | 30 |
| 31 | 9·453768 | 710 | 9·981699 | 63 | 9·472068 | 772 | 10·527932 | 29 |
| 32 | 454194 | 709 | 981662 | 63 | 472532 | 771 | 527468 | 28 |
| 33 | 454619 | 708 | 981625 | 63 | 472995 | 771 | 527005 | 27 |
| 34 | 455044 | 707 | 981587 | 63 | 473457 | 770 | 526543 | 26 |
| 35 | 455469 | 707 | 981549 | 63 | 473919 | 769 | 526081 | 25 |
| 36 | 455893 | 706 | 981512 | 63 | 474381 | 769 | 525619 | 24 |
| 37 | 456316 | 705 | 981474 | 63 | 474842 | 768 | 525158 | 23 |
| 38 | 456739 | 704 | 981436 | 63 | 475303 | 767 | 524697 | 22 |
| 39 | 457162 | 704 | 981399 | 63 | 475763 | 767 | 524237 | 21 |
| 40 | 457584 | 703 | 981361 | 63 | 476223 | 766 | 523777 | 20 |
| 41 | 9·458006 | 702 | 9·981323 | 63 | 9·476683 | 765 | 10·523317 | 19 |
| 42 | 458427 | 701 | 981285 | 63 | 477142 | 765 | 522858 | 18 |
| 43 | 458848 | 701 | 981247 | 63 | 477601 | 764 | 522399 | 17 |
| 44 | 459268 | 700 | 981209 | 63 | 478059 | 763 | 521941 | 16 |
| 45 | 459688 | 699 | 981171 | 63 | 478517 | 763 | 521483 | 15 |
| 46 | 460108 | 698 | 981133 | 64 | 478975 | 762 | 521025 | 14 |
| 47 | 460527 | 698 | 981095 | 64 | 479432 | 761 | 520568 | 13 |
| 48 | 460946 | 697 | 981057 | 64 | 479889 | 761 | 520111 | 12 |
| 49 | 461364 | 696 | 981019 | 64 | 480345 | 760 | 519655 | 11 |
| 50 | 461782 | 695 | 980981 | 64 | 480801 | 759 | 519199 | 10 |
| 51 | 9·462199 | 695 | 9·980942 | 64 | 9·481257 | 759 | 10·518743 | 9 |
| 52 | 462616 | 694 | 980904 | 64 | 481712 | 758 | 518288 | 8 |
| 53 | 463032 | 693 | 980866 | 64 | 482167 | 757 | 517833 | 7 |
| 54 | 463448 | 693 | 980827 | 64 | 482621 | 757 | 517379 | 6 |
| 55 | 463864 | 692 | 980789 | 64 | 483075 | 756 | 516925 | 5 |
| 56 | 464279 | 691 | 980750 | 64 | 483529 | 755 | 516471 | 4 |
| 57 | 464694 | 690 | 980712 | 64 | 483982 | 755 | 516018 | 3 |
| 58 | 465108 | 690 | 980673 | 64 | 484435 | 754 | 515565 | 2 |
| 59 | 465522 | 689 | 980635 | 64 | 484887 | 753 | 515113 | 1 |
| 60 | 465935 | 688 | 980596 | 64 | 485339 | 753 | 514661 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·465935 | 688 | 9·980596 | 64 | 9·485339 | 755 | 10·514661 | 60 |
| 1 | 466348 | 688 | 980558 | 64 | 485791 | 752 | 514209 | 59 |
| 2 | 466761 | 687 | 980519 | 65 | 486242 | 751 | 513758 | 58 |
| 3 | 467173 | 686 | 980480 | 65 | 486693 | 751 | 513307 | 57 |
| 4 | 467585 | 685 | 980442 | 65 | 487143 | 750 | 512857 | 56 |
| 5 | 467996 | 685 | 980403 | 65 | 487593 | 749 | 512407 | 55 |
| 6 | 468407 | 684 | 980364 | 65 | 488043 | 749 | 511957 | 54 |
| 7 | 468817 | 683 | 980325 | 65 | 488492 | 748 | 511508 | 53 |
| 8 | 469227 | 683 | 980286 | 65 | 488941 | 747 | 511059 | 52 |
| 9 | 469637 | 682 | 980247 | 65 | 489390 | 747 | 510610 | 51 |
| 10 | 470046 | 681 | 980208 | 65 | 489838 | 746 | 510162 | 50 |
| 11 | 9·470455 | 680 | 9·980169 | 65 | 9·490286 | 746 | 10·509714 | 49 |
| 12 | 470863 | 680 | 980130 | 65 | 490733 | 745 | 509267 | 48 |
| 13 | 471271 | 679 | 980091 | 65 | 491180 | 744 | 508820 | 47 |
| 14 | 471679 | 678 | 980052 | 65 | 491627 | 744 | 508373 | 46 |
| 15 | 472086 | 678 | 980012 | 65 | 492073 | 743 | 507927 | 45 |
| 16 | 472492 | 677 | 979973 | 65 | 492519 | 743 | 507481 | 44 |
| 17 | 472898 | 676 | 979934 | 66 | 492965 | 742 | 507035 | 43 |
| 18 | 473304 | 676 | 979895 | 66 | 493410 | 741 | 506590 | 42 |
| 19 | 473710 | 675 | 979855 | 66 | 493854 | 740 | 506146 | 41 |
| 20 | 474115 | 674 | 979816 | 66 | 494299 | 740 | 505701 | 40 |
| 21 | 9·474519 | 674 | 9·979776 | 66 | 9·494743 | 740 | 10·505257 | 39 |
| 22 | 474923 | 673 | 979737 | 66 | 495186 | 739 | 504814 | 38 |
| 23 | 475327 | 672 | 979697 | 66 | 495630 | 738 | 504370 | 37 |
| 24 | 475730 | 672 | 979658 | 66 | 496073 | 737 | 503927 | 36 |
| 25 | 476133 | 671 | 979618 | 66 | 496515 | 737 | 503485 | 35 |
| 26 | 476536 | 670 | 979579 | 66 | 496957 | 736 | 503043 | 34 |
| 27 | 476938 | 669 | 979539 | 66 | 497399 | 736 | 502601 | 33 |
| 28 | 477340 | 669 | 979499 | 66 | 497841 | 735 | 502159 | 32 |
| 29 | 477741 | 668 | 979459 | 66 | 498282 | 734 | 501718 | 31 |
| 30 | 478142 | 667 | 979420 | 66 | 498722 | 734 | 501278 | 30 |
| 31 | 9·478542 | 667 | 9·979380 | 66 | 9·499163 | 733 | 10·500837 | 29 |
| 32 | 478942 | 666 | 979340 | 66 | 499603 | 733 | 500397 | 28 |
| 33 | 479342 | 665 | 979300 | 67 | 500042 | 732 | 499958 | 27 |
| 34 | 479741 | 665 | 979260 | 67 | 500481 | 731 | 499519 | 26 |
| 35 | 480140 | 664 | 979220 | 67 | 500920 | 731 | 499080 | 25 |
| 36 | 480539 | 663 | 979180 | 67 | 501359 | 730 | 498641 | 24 |
| 37 | 480937 | 663 | 979140 | 67 | 501797 | 730 | 498203 | 23 |
| 38 | 481334 | 662 | 979100 | 67 | 502235 | 729 | 497765 | 22 |
| 39 | 481731 | 661 | 979059 | 67 | 502672 | 728 | 497328 | 21 |
| 40 | 482128 | 661 | 979019 | 67 | 503109 | 728 | 496891 | 20 |
| 41 | 9·482525 | 660 | 9·978979 | 67 | 9·503546 | 727 | 10·496454 | 19 |
| 42 | 482921 | 659 | 978939 | 67 | 503982 | 727 | 496018 | 18 |
| 43 | 483316 | 659 | 978898 | 67 | 504418 | 726 | 495582 | 17 |
| 44 | 483712 | 658 | 978858 | 67 | 504854 | 725 | 495146 | 16 |
| 45 | 484107 | 657 | 978817 | 67 | 505289 | 725 | 494711 | 15 |
| 46 | 484501 | 657 | 978777 | 67 | 505724 | 724 | 494276 | 14 |
| 47 | 484895 | 656 | 978736 | 67 | 506159 | 724 | 493841 | 13 |
| 48 | 485289 | 655 | 978696 | 68 | 506593 | 723 | 493407 | 12 |
| 49 | 485682 | 655 | 978655 | 68 | 507027 | 722 | 492973 | 11 |
| 50 | 486075 | 654 | 978615 | 68 | 507460 | 722 | 492540 | 10 |
| 51 | 9·486467 | 653 | 9·978574 | 68 | 9·507893 | 721 | 10·492107 | 9 |
| 52 | 486860 | 653 | 978533 | 68 | 508326 | 721 | 491674 | 8 |
| 53 | 487251 | 652 | 978493 | 68 | 508759 | 720 | 491241 | 7 |
| 54 | 487643 | 651 | 978452 | 68 | 509191 | 719 | 490809 | 6 |
| 55 | 488034 | 651 | 978411 | 68 | 509622 | 719 | 490378 | 5 |
| 56 | 488424 | 650 | 978370 | 68 | 510054 | 718 | 489946 | 4 |
| 57 | 488814 | 650 | 978329 | 68 | 510485 | 718 | 489515 | 3 |
| 58 | 489204 | 649 | 978288 | 68 | 510916 | 717 | 489084 | 2 |
| 59 | 489593 | 648 | 978247 | 68 | 511346 | 716 | 488654 | 1 |
| 60 | 489982 | 648 | 978206 | 68 | 511776 | 716 | 488224 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·489982 | 648 | 9·978206 | 68 | 9·511776 | 716 | 10·488224 | 60 |
| 1 | 490371 | 648 | 978165 | 68 | 512206 | 716 | 487794 | 59 |
| 2 | 490759 | 647 | 978124 | 68 | 512635 | 715 | 487365 | 58 |
| 3 | 491147 | 646 | 978083 | 69 | 513064 | 714 | 486936 | 57 |
| 4 | 491535 | 646 | 978042 | 69 | 513493 | 714 | 486507 | 56 |
| 5 | 491922 | 645 | 978001 | 69 | 513921 | 713 | 486079 | 55 |
| 6 | 492308 | 644 | 977959 | 69 | 514349 | 713 | 485651 | 54 |
| 7 | 492695 | 644 | 977918 | 69 | 514777 | 712 | 485223 | 53 |
| 8 | 493081 | 643 | 977877 | 69 | 515204 | 712 | 484796 | 52 |
| 9 | 493466 | 642 | 977835 | 69 | 515631 | 711 | 484369 | 51 |
| 10 | 493851 | 642 | 977794 | 69 | 516057 | 710 | 483943 | 50 |
| 11 | 9·494236 | 641 | 9·977752 | 69 | 9·516484 | 710 | 10·483516 | 49 |
| 12 | 494621 | 641 | 977711 | 69 | 516910 | 709 | 483090 | 48 |
| 13 | 495005 | 640 | 977669 | 69 | 517335 | 709 | 482665 | 47 |
| 14 | 495388 | 639 | 977628 | 69 | 517761 | 708 | 482239 | 46 |
| 15 | 495772 | 639 | 977586 | 69 | 518185 | 708 | 481815 | 45 |
| 16 | 496154 | 638 | 977544 | 70 | 518610 | 707 | 481390 | 44 |
| 17 | 496537 | 637 | 977503 | 70 | 519034 | 706 | 480966 | 43 |
| 18 | 496919 | 637 | 977461 | 70 | 519458 | 706 | 480542 | 42 |
| 19 | 497301 | 636 | 977419 | 70 | 519882 | 705 | 480118 | 41 |
| 20 | 497682 | 636 | 977377 | 70 | 520305 | 705 | 479695 | 40 |
| 21 | 9·498064 | 635 | 9·977335 | 70 | 9·520728 | 704 | 10·479272 | 39 |
| 22 | 498444 | 634 | 977293 | 70 | 521151 | 703 | 478849 | 38 |
| 23 | 498825 | 634 | 977251 | 70 | 521573 | 703 | 478427 | 37 |
| 24 | 499204 | 633 | 977209 | 70 | 521995 | 703 | 478005 | 36 |
| 25 | 499584 | 632 | 977167 | 70 | 522417 | 702 | 477583 | 35 |
| 26 | 499963 | 632 | 977125 | 70 | 522838 | 702 | 477162 | 34 |
| 27 | 500342 | 631 | 977083 | 70 | 523259 | 701 | 476741 | 33 |
| 28 | 500721 | 631 | 977041 | 70 | 523680 | 701 | 476320 | 32 |
| 29 | 501099 | 630 | 976999 | 70 | 524100 | 700 | 475900 | 31 |
| 30 | 501476 | 629 | 976957 | 70 | 524520 | 699 | 475480 | 30 |
| 31 | 9·501854 | 629 | 9·976914 | 70 | 9·524939 | 699 | 10·475061 | 29 |
| 32 | 502231 | 628 | 976872 | 71 | 525359 | 698 | 474641 | 28 |
| 33 | 502607 | 628 | 976830 | 71 | 525778 | 698 | 474222 | 27 |
| 34 | 502984 | 627 | 976787 | 71 | 526197 | 697 | 473803 | 26 |
| 35 | 503360 | 626 | 976745 | 71 | 526615 | 697 | 473385 | 25 |
| 36 | 503735 | 626 | 976702 | 71 | 527033 | 696 | 472967 | 24 |
| 37 | 504110 | 625 | 976660 | 71 | 527451 | 696 | 472549 | 23 |
| 38 | 504485 | 625 | 976617 | 71 | 527868 | 695 | 472132 | 22 |
| 39 | 504860 | 624 | 976574 | 71 | 528285 | 695 | 471715 | 21 |
| 40 | 505234 | 623 | 976532 | 71 | 528702 | 694 | 471298 | 20 |
| 41 | 9·505608 | 623 | 9·976489 | 71 | 9·529119 | 693 | 10·470881 | 19 |
| 42 | 505981 | 622 | 976446 | 71 | 529535 | 693 | 470465 | 18 |
| 43 | 506354 | 622 | 976404 | 71 | 529950 | 693 | 470050 | 17 |
| 44 | 506727 | 621 | 976361 | 71 | 530366 | 692 | 469634 | 16 |
| 45 | 507099 | 620 | 976318 | 71 | 530781 | 691 | 469219 | 15 |
| 46 | 507471 | 620 | 976275 | 71 | 531196 | 691 | 468804 | 14 |
| 47 | 507843 | 619 | 976232 | 72 | 531611 | 690 | 468389 | 13 |
| 48 | 508214 | 619 | 976189 | 72 | 532025 | 690 | 467975 | 12 |
| 49 | 508585 | 618 | 976146 | 72 | 532439 | 689 | 467561 | 11 |
| 50 | 508956 | 618 | 976103 | 72 | 532853 | 689 | 467147 | 10 |
| 51 | 9·509326 | 617 | 9·976060 | 72 | 9·533266 | 688 | 10·466734 | 9 |
| 52 | 509696 | 616 | 976017 | 72 | 533679 | 688 | 466321 | 8 |
| 53 | 510065 | 616 | 975974 | 72 | 534092 | 687 | 465908 | 7 |
| 54 | 510434 | 615 | 975930 | 72 | 534504 | 687 | 465496 | 6 |
| 55 | 510803 | 615 | 975887 | 72 | 534916 | 686 | 465084 | 5 |
| 56 | 511172 | 614 | 975844 | 72 | 535328 | 686 | 464672 | 4 |
| 57 | 511540 | 613 | 975800 | 72 | 535739 | 685 | 464261 | 3 |
| 58 | 511907 | 613 | 975757 | 72 | 536150 | 685 | 463850 | 2 |
| 59 | 512275 | 612 | 975714 | 72 | 536561 | 684 | 463439 | 1 |
| 60 | 512642 | 612 | 975670 | 72 | 536972 | 684 | 463028 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·512642 | 612 | 9·975670 | 73 | 9·536972 | 684 | 10·463028 | 60 |
| 1 | 513009 | 611 | 975627 | 73 | 537382 | 683 | 462618 | 59 |
| 2 | 513375 | 611 | 975583 | 73 | 537792 | 683 | 462208 | 58 |
| 3 | 513741 | 610 | 975539 | 73 | 538202 | 682 | 461798 | 57 |
| 4 | 514107 | 609 | 975496 | 73 | 538611 | 682 | 461389 | 56 |
| 5 | 514472 | 609 | 975452 | 73 | 539020 | 681 | 460980 | 55 |
| 6 | 514837 | 608 | 975408 | 73 | 539429 | 681 | 460571 | 54 |
| 7 | 515202 | 608 | 975365 | 73 | 539837 | 680 | 460163 | 53 |
| 8 | 515566 | 607 | 975321 | 73 | 540245 | 680 | 459755 | 52 |
| 9 | 515930 | 607 | 975277 | 73 | 540653 | 679 | 459347 | 51 |
| 10 | 516294 | 606 | 975233 | 73 | 541061 | 679 | 458939 | 50 |
| 11 | 9·516657 | 605 | 9·975189 | 73 | 9·541468 | 678 | 10·458532 | 49 |
| 12 | 517020 | 605 | 975145 | 73 | 541875 | 678 | 458125 | 48 |
| 13 | 517382 | 604 | 975101 | 73 | 542281 | 677 | 457719 | 47 |
| 14 | 517745 | 604 | 975057 | 73 | 542688 | 677 | 457312 | 46 |
| 15 | 518107 | 603 | 975013 | 73 | 543094 | 676 | 456906 | 45 |
| 16 | 518468 | 603 | 974969 | 74 | 543499 | 676 | 456501 | 44 |
| 17 | 518829 | 602 | 974925 | 74 | 543905 | 675 | 456095 | 43 |
| 18 | 519190 | 601 | 974880 | 74 | 544310 | 675 | 455690 | 42 |
| 19 | 519551 | 601 | 974836 | 74 | 544715 | 674 | 455285 | 41 |
| 20 | 519911 | 600 | 974792 | 74 | 545119 | 674 | 454881 | 40 |
| 21 | 9·520271 | 600 | 9·974748 | 74 | 9·545524 | 673 | 10·454476 | 39 |
| 22 | 520631 | 599 | 974703 | 74 | 545928 | 673 | 454072 | 38 |
| 23 | 520990 | 599 | 974659 | 74 | 546331 | 672 | 453669 | 37 |
| 24 | 521349 | 598 | 974614 | 74 | 546735 | 672 | 453265 | 36 |
| 25 | 521707 | 598 | 974570 | 74 | 547138 | 671 | 452862 | 35 |
| 26 | 522066 | 597 | 974525 | 74 | 547540 | 671 | 452460 | 34 |
| 27 | 522424 | 596 | 974481 | 74 | 547943 | 670 | 452057 | 33 |
| 28 | 522781 | 596 | 974436 | 74 | 548345 | 670 | 451655 | 32 |
| 29 | 523138 | 595 | 974391 | 74 | 548747 | 669 | 451253 | 31 |
| 30 | 523495 | 595 | 974347 | 75 | 549149 | 669 | 450851 | 30 |
| 31 | 9·523852 | 594 | 9·974302 | 75 | 9·549550 | 668 | 10·450450 | 29 |
| 32 | 524208 | 594 | 974257 | 75 | 549951 | 668 | 450049 | 28 |
| 33 | 524564 | 593 | 974212 | 75 | 550352 | 667 | 449648 | 27 |
| 34 | 524920 | 593 | 974167 | 75 | 550752 | 667 | 449248 | 26 |
| 35 | 525275 | 592 | 974122 | 75 | 551152 | 666 | 448848 | 25 |
| 36 | 525630 | 591 | 974077 | 75 | 551552 | 666 | 448448 | 24 |
| 37 | 525984 | 591 | 974032 | 75 | 551952 | 665 | 448048 | 23 |
| 38 | 526339 | 590 | 973987 | 75 | 552351 | 665 | 447649 | 22 |
| 39 | 526693 | 590 | 973942 | 75 | 552750 | 665 | 447250 | 21 |
| 40 | 527046 | 589 | 973897 | 75 | 553149 | 664 | 446851 | 20 |
| 41 | 9·527400 | 589 | 9·973852 | 75 | 9·553548 | 664 | 10·446452 | 19 |
| 42 | 527753 | 588 | 973807 | 75 | 553946 | 663 | 446054 | 18 |
| 43 | 528105 | 588 | 973761 | 75 | 554344 | 663 | 445656 | 17 |
| 44 | 528458 | 587 | 973716 | 76 | 554741 | 662 | 445259 | 16 |
| 45 | 528810 | 587 | 973671 | 76 | 555139 | 662 | 444861 | 15 |
| 46 | 529161 | 586 | 973625 | 76 | 555536 | 661 | 444464 | 14 |
| 47 | 529513 | 586 | 973580 | 76 | 555933 | 661 | 444067 | 13 |
| 48 | 529864 | 585 | 973535 | 76 | 556329 | 660 | 443671 | 12 |
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| 50 | 530565 | 584 | 973444 | 76 | 557121 | 659 | 442879 | 10 |
| 51 | 9·530915 | 584 | 9·973398 | 76 | 9·557517 | 659 | 10·442483 | 9 |
| 52 | 531265 | 583 | 973352 | 76 | 557913 | 659 | 442087 | 8 |
| 53 | 531614 | 582 | 973307 | 76 | 558308 | 658 | 441692 | 7 |
| 54 | 531963 | 582 | 973261 | 76 | 558702 | 658 | 441298 | 6 |
| 55 | 532312 | 581 | 973215 | 76 | 559097 | 657 | 440903 | 5 |
| 56 | 532661 | 581 | 973169 | 76 | 559491 | 657 | 440509 | 4 |
| 57 | 533009 | 580 | 973124 | 76 | 559885 | 656 | 440115 | 3 |
| 58 | 533357 | 580 | 973078 | 76 | 560279 | 656 | 439721 | 2 |
| 59 | 533704 | 579 | 973032 | 77 | 560673 | 655 | 439327 | 1 |
| 60 | 534052 | 578 | 972986 | 77 | 561066 | 655 | 438934 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 1 | 534399 | 577 | 972940 | 77 | 561459 | 654 | 438541 | 59 |
| 2 | 534745 | 577 | 972894 | 77 | 561851 | 654 | 438149 | 58 |
| 3 | 535092 | 577 | 972848 | 77 | 562244 | 653 | 437756 | 57 |
| 4 | 535438 | 576 | 972802 | 77 | 562636 | 653 | 437364 | 56 |
| 5 | 535783 | 576 | 972755 | 77 | 563028 | 653 | 436972 | 55 |
| 6 | 536129 | 575 | 972709 | 77 | 563419 | 652 | 436581 | 54 |
| 7 | 536474 | 574 | 972663 | 77 | 563811 | 652 | 436189 | 53 |
| 8 | 536818 | 574 | 972617 | 77 | 564202 | 651 | 435798 | 52 |
| 9 | 537163 | 573 | 972570 | 77 | 564592 | 651 | 435408 | 51 |
| 10 | 537507 | 573 | 972524 | 77 | 564983 | 650 | 435017 | 50 |
| 11 | 9·537851 | 572 | 9·972478 | 77 | 9·565373 | 650 | 10·434627 | 49 |
| 12 | 538194 | 572 | 972431 | 78 | 565763 | 649 | 434237 | 48 |
| 13 | 538538 | 571 | 972385 | 78 | 566153 | 649 | 433847 | 47 |
| 14 | 538880 | 571 | 972338 | 78 | 566542 | 649 | 433458 | 46 |
| 15 | 539223 | 570 | 972291 | 78 | 566932 | 648 | 433068 | 45 |
| 16 | 539565 | 570 | 972245 | 78 | 567320 | 648 | 432680 | 44 |
| 17 | 539907 | 569 | 972198 | 78 | 567709 | 647 | 432291 | 43 |
| 18 | 540249 | 569 | 972151 | 78 | 568098 | 647 | 431902 | 42 |
| 19 | 540590 | 568 | 972105 | 78 | 568486 | 646 | 431514 | 41 |
| 20 | 540931 | 568 | 972058 | 78 | 568873 | 646 | 431127 | 40 |
| 21 | 9·541272 | 567 | 9·972011 | 78 | 9·569261 | 645 | 10·430739 | 39 |
| 22 | 541613 | 567 | 971964 | 78 | 569648 | 645 | 430352 | 38 |
| 23 | 541953 | 566 | 971917 | 78 | 570035 | 645 | 429965 | 37 |
| 24 | 542293 | 566 | 971870 | 78 | 570422 | 644 | 429578 | 36 |
| 25 | 542632 | 565 | 971823 | 78 | 570809 | 644 | 429191 | 35 |
| 26 | 542971 | 565 | 971776 | 78 | 571195 | 643 | 428805 | 34 |
| 27 | 543310 | 564 | 971729 | 79 | 571581 | 643 | 428419 | 33 |
| 28 | 543649 | 564 | 971682 | 79 | 571967 | 642 | 428033 | 32 |
| 29 | 543987 | 563 | 971635 | 79 | 572352 | 642 | 427648 | 31 |
| 30 | 544325 | 563 | 971588 | 79 | 572738 | 642 | 427262 | 30 |
| 31 | 9·544663 | 562 | 9·971540 | 79 | 9·573123 | 641 | 10·426877 | 29 |
| 32 | 545000 | 562 | 971493 | 79 | 573507 | 641 | 426493 | 28 |
| 33 | 545338 | 561 | 971446 | 79 | 573892 | 640 | 426108 | 27 |
| 34 | 545674 | 561 | 971398 | 79 | 574276 | 640 | 425724 | 26 |
| 35 | 546011 | 560 | 971351 | 79 | 574660 | 639 | 425340 | 25 |
| 36 | 546347 | 560 | 971303 | 79 | 575044 | 639 | 424956 | 24 |
| 37 | 546683 | 559 | 971256 | 79 | 575427 | 639 | 424573 | 23 |
| 38 | 547019 | 559 | 971208 | 79 | 575810 | 638 | 424190 | 22 |
| 39 | 547354 | 558 | 971161 | 79 | 576193 | 638 | 423807 | 21 |
| 40 | 547689 | 558 | 971113 | 79 | 576576 | 637 | 423424 | 20 |
| 41 | 9·548024 | 557 | 9·971066 | 80 | 9·576958 | 637 | 10·423041 | 19 |
| 42 | 548359 | 557 | 971018 | 80 | 577341 | 636 | 422659 | 18 |
| 43 | 548693 | 556 | 970970 | 80 | 577723 | 636 | 422277 | 17 |
| 44 | 549027 | 556 | 970922 | 80 | 578104 | 636 | 421896 | 16 |
| 45 | 549360 | 555 | 970874 | 80 | 578486 | 635 | 421514 | 15 |
| 46 | 549693 | 555 | 970827 | 80 | 578867 | 635 | 421133 | 14 |
| 47 | 550026 | 554 | 970779 | 80 | 579248 | 634 | 420752 | 13 |
| 48 | 550359 | 554 | 970731 | 80 | 579629 | 634 | 420371 | 12 |
| 49 | 550692 | 553 | 970683 | 80 | 580009 | 634 | 419991 | 11 |
| 50 | 551024 | 553 | 970635 | 80 | 580389 | 633 | 419611 | 10 |
| 51 | 9·551356 | 552 | 9·970586 | 80 | 9·580769 | 633 | 10·419231 | 9 |
| 52 | 551687 | 552 | 970538 | 80 | 581149 | 632 | 418851 | 8 |
| 53 | 552018 | 552 | 970490 | 80 | 581528 | 632 | 418472 | 7 |
| 54 | 552349 | 551 | 970442 | 80 | 581907 | 632 | 418093 | 6 |
| 55 | 552680 | 551 | 970394 | 80 | 582286 | 631 | 417714 | 5 |
| 56 | 553010 | 550 | 970345 | 81 | 582665 | 631 | 417335 | 4 |
| 57 | 553341 | 550 | 970297 | 81 | 583043 | 630 | 416957 | 3 |
| 58 | 553670 | 549 | 970249 | 81 | 583422 | 630 | 416578 | 2 |
| 59 | 554000 | 549 | 970200 | 81 | 583800 | 629 | 416200 | 1 |
| 60 | 554329 | 548 | 970152 | 81 | 584177 | 629 | 415823 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·554329 | 548 | 9·970152 | 81 | 9·584177 | 629 | 10·415823 | 60 |
| 1 | 554658 | 548 | 970103 | 81 | 584555 | 629 | 415445 | 59 |
| 2 | 554987 | 547 | 960055 | 81 | 584932 | 628 | 415068 | 58 |
| 3 | 555315 | 547 | 970006 | 81 | 585309 | 628 | 414691 | 57 |
| 4 | 555643 | 546 | 969957 | 81 | 585686 | 627 | 414314 | 56 |
| 5 | 555971 | 546 | 969909 | 81 | 586062 | 627 | 413938 | 55 |
| 6 | 556299 | 545 | 969860 | 81 | 586439 | 627 | 413561 | 54 |
| 7 | 556626 | 545 | 969811 | 81 | 586815 | 626 | 413185 | 53 |
| 8 | 556953 | 544 | 969762 | 81 | 587190 | 626 | 412810 | 52 |
| 9 | 557280 | 544 | 969714 | 81 | 587566 | 625 | 412434 | 51 |
| 10 | 557606 | 543 | 969665 | 81 | 587941 | 625 | 412059 | 50 |
| 11 | 9 557932 | 543 | 9·969616 | 82 | 9·588316 | 625 | 10·411684 | 49 |
| 12 | 558258 | 543 | 969567 | 82 | 588691 | 624 | 411309 | 48 |
| 13 | 558583 | 542 | 969518 | 82 | 589066 | 624 | 410934 | 47 |
| 14 | 558909 | 542 | 969469 | 82 | 589440 | 623 | 410560 | 46 |
| 15 | 559234 | 541 | 969420 | 82 | 589814 | 623 | 410186 | 45 |
| 16 | 559558 | 541 | 969370 | 82 | 590188 | 623 | 409812 | 44 |
| 17 | 559883 | 540 | 969321 | 82 | 590562 | 622 | 409438 | 43 |
| 18 | 560207 | 540 | 969272 | 82 | 590935 | 622 | 409065 | 42 |
| 19 | 560531 | 539 | 960223 | 82 | 591308 | 622 | 408692 | 41 |
| 20 | 560855 | 539 | 969173 | 82 | 591681 | 621 | 408319 | 40 |
| 21 | 9·561178 | 538 | 9·969124 | 82 | 9·592054 | 621 | 10·407946 | 39 |
| 22 | 561501 | 538 | 969075 | 82 | 592426 | 620 | 407574 | 38 |
| 23 | 561824 | 537 | 969025 | 82 | 592798 | 620 | 407202 | 37 |
| 24 | 562146 | 537 | 968976 | 82 | 593170 | 619 | 406829 | 36 |
| 25 | 562468 | 536 | 968926 | 83 | 593542 | 619 | 406458 | 35 |
| 26 | 562790 | 536 | 968877 | 83 | 593914 | 618 | 406086 | 34 |
| 27 | 563112 | 536 | 968827 | 83 | 594285 | 618 | 405715 | 33 |
| 28 | 563433 | 535 | 968777 | 83 | 594656 | 618 | 405344 | 32 |
| 29 | 563755 | 535 | 968728 | 83 | 595027 | 617 | 404973 | 31 |
| 30 | 564075 | 534 | 968678 | 83 | 595398 | 617 | 404602 | 30 |
| 31 | 9·564396 | 534 | 9·968628 | 83 | 9·595768 | 617 | 10·404232 | 29 |
| 32 | 564716 | 533 | 968578 | 83 | 596138 | 616 | 403862 | 28 |
| 33 | 565036 | 533 | 968528 | 83 | 596508 | 616 | 403492 | 27 |
| 34 | 565356 | 532 | 968479 | 83 | 596878 | 616 | 403122 | 26 |
| 35 | 565676 | 532 | 968429 | 83 | 597247 | 615 | 402753 | 25 |
| 36 | 565995 | 531 | 968379 | 83 | 597616 | 615 | 402384 | 24 |
| 37 | 566314 | 531 | 968329 | 83 | 597985 | 615 | 402015 | 23 |
| 38 | 566632 | 531 | 968278 | 83 | 598354 | 614 | 401646 | 22 |
| 39 | 566951 | 530 | 968228 | 84 | 598722 | 614 | 401278 | 21 |
| 40 | 567269 | 530 | 968178 | 84 | 599091 | 613 | 400909 | 20 |
| 41 | 9·567587 | 529 | 9·968128 | 84 | 9·599459 | 613 | 10·400541 | 19 |
| 42 | 567904 | 529 | 968078 | 84 | 599827 | 613 | 400173 | 18 |
| 43 | 568222 | 528 | 968027 | 84 | 600194 | 612 | 399806 | 17 |
| 44 | 568539 | 528 | 967977 | 84 | 600562 | 612 | 399438 | 16 |
| 45 | 568856 | 528 | 967927 | 84 | 600929 | 611 | 399071 | 15 |
| 46 | 569172 | 527 | 967876 | 84 | 601296 | 611 | 398704 | 14 |
| 47 | 569488 | 527 | 967826 | 84 | 601662 | 611 | 398338 | 13 |
| 48 | 569804 | 526 | 967775 | 84 | 602029 | 610 | 397971 | 12 |
| 49 | 570120 | 526 | 967725 | 84 | 602395 | 610 | 397605 | 11 |
| 50 | 570435 | 525 | 967674 | 84 | 602761 | 610 | 397239 | 10 |
| 51 | 9·570751 | 525 | 9·967624 | 84 | 9·603127 | 609 | 10·396873 | 9 |
| 52 | 571066 | 524 | 967573 | 84 | 603493 | 609 | 396507 | 8 |
| 53 | 571380 | 524 | 967522 | 85 | 603858 | 609 | 396142 | 7 |
| 54 | 571695 | 523 | 967471 | 85 | 604223 | 608 | 395777 | 6 |
| 55 | 572009 | 523 | 967421 | 85 | 604588 | 608 | 395412 | 5 |
| 56 | 572323 | 523 | 967370 | 85 | 604953 | 607 | 395047 | 4 |
| 57 | 572636 | 522 | 967319 | 85 | 605317 | 607 | 394683 | 3 |
| 58 | 572950 | 522 | 967268 | 85 | 605682 | 607 | 394318 | 2 |
| 59 | 573263 | 521 | 967217 | 85 | 606046 | 606 | 393954 | 1 |
| 60 | 573575 | 521 | 967166 | 85 | 606410 | 606 | 393590 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·573575 | 521 | 9·967166 | 85 | 9·606410 | 606 | 10·393590 | 60 |
| 1 | 573888 | 520 | 967115 | 85 | 606773 | 606 | 393227 | 59 |
| 2 | 574200 | 520 | 967064 | 85 | 607137 | 605 | 392863 | 58 |
| 3 | 574512 | 519 | 967013 | 85 | 607500 | 605 | 392500 | 57 |
| 4 | 574824 | 519 | 966961 | 85 | 607863 | 604 | 392137 | 56 |
| 5 | 575136 | 519 | 966910 | 85 | 608225 | 604 | 391775 | 55 |
| 6 | 575447 | 518 | 966859 | 85 | 608588 | 604 | 391412 | 54 |
| 7 | 575758 | 518 | 966808 | 85 | 608950 | 603 | 391050 | 53 |
| 8 | 576069 | 517 | 966756 | 86 | 609312 | 603 | 390688 | 52 |
| 9 | 576379 | 517 | 966705 | 86 | 609674 | 603 | 390326 | 51 |
| 10 | 576689 | 516 | 966653 | 86 | 610036 | 602 | 389964 | 50 |
| 11 | 9·576999 | 516 | 9·966602 | 86 | 9·610397 | 602 | 10·389603 | 49 |
| 12 | 577309 | 516 | 966550 | 86 | 610759 | 602 | 389241 | 48 |
| 13 | 577618 | 515 | 966499 | 86 | 611120 | 601 | 388880 | 47 |
| 14 | 577927 | 515 | 966447 | 86 | 611480 | 601 | 388520 | 46 |
| 15 | 578236 | 514 | 966395 | 86 | 611841 | 601 | 388159 | 45 |
| 16 | 578545 | 514 | 966344 | 86 | 612201 | 600 | 387799 | 44 |
| 17 | 578853 | 513 | 966292 | 86 | 612561 | 600 | 387439 | 43 |
| 18 | 579162 | 513 | 966240 | 86 | 612921 | 600 | 387079 | 42 |
| 19 | 579470 | 513 | 966188 | 86 | 613281 | 599 | 386719 | 41 |
| 20 | 579777 | 512 | 966136 | 86 | 613641 | 599 | 386359 | 40 |
| 21 | 9·580085 | 512 | 9·966085 | 87 | 9·614000 | 598 | 10·386000 | 39 |
| 22 | 580392 | 511 | 966033 | 87 | 614359 | 598 | 385641 | 38 |
| 23 | 580699 | 511 | 965981 | 87 | 614718 | 598 | 385282 | 37 |
| 24 | 581005 | 511 | 965928 | 87 | 615077 | 597 | 384923 | 36 |
| 25 | 581312 | 510 | 965876 | 87 | 615435 | 597 | 384565 | 35 |
| 26 | 581618 | 510 | 965824 | 87 | 615793 | 597 | 384207 | 34 |
| 27 | 581924 | 509 | 965772 | 87 | 616151 | 596 | 383849 | 33 |
| 28 | 582229 | 509 | 965720 | 87 | 616509 | 596 | 383491 | 32 |
| 29 | 582535 | 509 | 965668 | 87 | 616867 | 596 | 383133 | 31 |
| 30 | 582840 | 508 | 965615 | 87 | 617224 | 595 | 382776 | 30 |
| 31 | 9·583145 | 508 | 9·965563 | 87 | 9·617582 | 595 | 10·382418 | 29 |
| 32 | 583449 | 507 | 965511 | 87 | 617939 | 595 | 382061 | 28 |
| 33 | 583754 | 507 | 965458 | 87 | 618295 | 594 | 381705 | 27 |
| 34 | 584058 | 506 | 965406 | 87 | 618652 | 594 | 381348 | 26 |
| 35 | 584361 | 506 | 965353 | 88 | 619008 | 594 | 380992 | 25 |
| 36 | 584665 | 506 | 965301 | 88 | 619364 | 593 | 380636 | 24 |
| 37 | 584968 | 505 | 965248 | 88 | 619721 | 593 | 380279 | 23 |
| 38 | 585272 | 505 | 965195 | 88 | 620076 | 593 | 379924 | 22 |
| 39 | 585574 | 504 | 965143 | 88 | 620432 | 592 | 379568 | 21 |
| 40 | 585877 | 504 | 965090 | 88 | 620787 | 592 | 379213 | 20 |
| 41 | 9·586179 | 503 | 9·965037 | 88 | 9·621142 | 592 | 10·378858 | 19 |
| 42 | 586482 | 503 | 964984 | 88 | 621497 | 591 | 378503 | 18 |
| 43 | 586783 | 503 | 964931 | 88 | 621852 | 591 | 378148 | 17 |
| 44 | 587085 | 502 | 964879 | 88 | 622207 | 590 | 377793 | 16 |
| 45 | 587386 | 502 | 964826 | 88 | 622561 | 590 | 377439 | 15 |
| 46 | 587688 | 501 | 964773 | 88 | 622915 | 590 | 377085 | 14 |
| 47 | 587989 | 501 | 964719 | 88 | 623269 | 589 | 376731 | 13 |
| 48 | 588289 | 501 | 964666 | 89 | 623623 | 589 | 376377 | 12 |
| 49 | 588590 | 500 | 964613 | 89 | 623976 | 589 | 376024 | 11 |
| 50 | 588890 | 500 | 964560 | 89 | 624330 | 588 | 375670 | 10 |
| 51 | 9·589190 | 499 | 9·964507 | 89 | 9·624683 | 588 | 10·375317 | 9 |
| 52 | 589489 | 499 | 964454 | 89 | 625036 | 588 | 374964 | 8 |
| 53 | 589789 | 499 | 964400 | 89 | 625388 | 587 | 374612 | 7 |
| 54 | 590088 | 498 | 964347 | 89 | 625741 | 587 | 374259 | 6 |
| 55 | 590387 | 498 | 964294 | 89 | 626093 | 587 | 373907 | 5 |
| 56 | 590686 | 497 | 964240 | 89 | 626445 | 586 | 373555 | 4 |
| 57 | 590984 | 497 | 964187 | 89 | 626797 | 586 | 373203 | 3 |
| 58 | 591282 | 497 | 964133 | 89 | 627149 | 586 | 372851 | 2 |
| 59 | 591580 | 496 | 964080 | 89 | 627501 | 585 | 372499 | 1 |
| 60 | 591878 | 496 | 964026 | 89 | 627852 | 585 | 372148 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·591878 | 496 | 9·964026 | 89 | 9·627852 | 585 | 10·372148 | 60 |
| 1 | 592176 | 495 | 963972 | 89 | 628203 | 585 | 371797 | 59 |
| 2 | 592473 | 495 | 963919 | 89 | 628554 | 585 | 371446 | 58 |
| 3 | 592770 | 495 | 963865 | 90 | 628905 | 584 | 371095 | 57 |
| 4 | 593067 | 494 | 963811 | 90 | 629255 | 584 | 370745 | 56 |
| 5 | 593363 | 494 | 963757 | 90 | 629606 | 583 | 370394 | 55 |
| 6 | 593659 | 493 | 963704 | 90 | 629956 | 583 | 370044 | 54 |
| 7 | 593955 | 493 | 963650 | 90 | 630306 | 583 | 369694 | 53 |
| 8 | 594251 | 493 | 963596 | 90 | 630656 | 583 | 369344 | 52 |
| 9 | 594547 | 492 | 963542 | 90 | 631005 | 582 | 368995 | 51 |
| 10 | 594842 | 492 | 963488 | 90 | 631355 | 582 | 368645 | 50 |
| 11 | 9·595137 | 491 | 9·963434 | 90 | 9·631704 | 582 | 10·368296 | 49 |
| 12 | 595432 | 491 | 963379 | 90 | 632053 | 581 | 367947 | 48 |
| 13 | 595727 | 491 | 963325 | 90 | 632401 | 581 | 367599 | 47 |
| 14 | 596021 | 490 | 963271 | 90 | 632750 | 581 | 367250 | 46 |
| 15 | 596315 | 490 | 963217 | 90 | 633098 | 580 | 366902 | 45 |
| 16 | 596609 | 489 | 963163 | 90 | 633447 | 580 | 366553 | 44 |
| 17 | 596903 | 489 | 963108 | 91 | 633795 | 580 | 366205 | 43 |
| 18 | 597196 | 489 | 963054 | 91 | 634143 | 579 | 365857 | 42 |
| 19 | 597490 | 488 | 962999 | 91 | 634490 | 579 | 365510 | 41 |
| 20 | 597783 | 488 | 962945 | 91 | 634838 | 579 | 365162 | 40 |
| 21 | 9·598075 | 487 | 9·962890 | 91 | 9·635185 | 578 | 10·364815 | 39 |
| 22 | 598368 | 487 | 962836 | 91 | 635532 | 578 | 364468 | 38 |
| 23 | 598660 | 487 | 962781 | 91 | 635879 | 578 | 364121 | 37 |
| 24 | 598952 | 486 | 962727 | 91 | 636226 | 577 | 363774 | 36 |
| 25 | 599244 | 486 | 962672 | 91 | 636572 | 577 | 363428 | 35 |
| 26 | 599536 | 485 | 962617 | 91 | 636919 | 577 | 363081 | 34 |
| 27 | 599827 | 485 | 962562 | 91 | 637265 | 577 | 362735 | 33 |
| 28 | 600118 | 485 | 962508 | 91 | 637611 | 576 | 362389 | 32 |
| 29 | 600409 | 484 | 962453 | 91 | 637956 | 576 | 362044 | 31 |
| 30 | 600700 | 484 | 962398 | 92 | 638302 | 576 | 361698 | 30 |
| 31 | 9·600990 | 484 | 9·962343 | 92 | 9·638647 | 575 | 10·361353 | 29 |
| 32 | 601280 | 483 | 962288 | 92 | 638992 | 575 | 361008 | 28 |
| 33 | 601570 | 483 | 962233 | 92 | 639337 | 575 | 360663 | 27 |
| 34 | 601860 | 482 | 962178 | 92 | 639682 | 574 | 360318 | 26 |
| 35 | 602150 | 482 | 962123 | 92 | 640027 | 574 | 359973 | 25 |
| 36 | 602439 | 482 | 962067 | 92 | 640371 | 574 | 359629 | 24 |
| 37 | 602728 | 481 | 962012 | 92 | 640716 | 573 | 359284 | 23 |
| 38 | 603017 | 481 | 961957 | 92 | 641060 | 573 | 358940 | 22 |
| 39 | 603305 | 481 | 961902 | 92 | 641404 | 573 | 358596 | 21 |
| 40 | 603594 | 480 | 961846 | 92 | 641747 | 572 | 358253 | 20 |
| 41 | 9·603882 | 480 | 9·961791 | 92 | 9·642091 | 572 | 10·357909 | 19 |
| 42 | 604170 | 479 | 961735 | 92 | 642434 | 572 | 357566 | 18 |
| 43 | 604457 | 479 | 961680 | 92 | 642777 | 572 | 357223 | 17 |
| 44 | 604745 | 479 | 961624 | 93 | 643120 | 571 | 356880 | 16 |
| 45 | 605032 | 478 | 961569 | 93 | 643463 | 571 | 356537 | 15 |
| 46 | 605319 | 478 | 961513 | 93 | 643806 | 571 | 356194 | 14 |
| 47 | 605606 | 478 | 961458 | 93 | 644148 | 570 | 355852 | 13 |
| 48 | 605892 | 477 | 961402 | 93 | 644490 | 570 | 355510 | 12 |
| 49 | 606179 | 477 | 961346 | 93 | 644832 | 570 | 355168 | 11 |
| 50 | 606465 | 476 | 961290 | 93 | 645174 | 569 | 354826 | 10 |
| 51 | 9·606751 | 476 | 9·961235 | 93 | 9·645516 | 569 | 10·354484 | 9 |
| 52 | 607036 | 476 | 961179 | 93 | 645857 | 569 | 354143 | 8 |
| 53 | 607322 | 475 | 961123 | 93 | 646199 | 569 | 353801 | 7 |
| 54 | 607607 | 475 | 961067 | 93 | 646540 | 568 | 353460 | 6 |
| 55 | 607892 | 474 | 961011 | 93 | 646881 | 568 | 353119 | 5 |
| 56 | 608177 | 474 | 960955 | 93 | 647222 | 568 | 352778 | 4 |
| 57 | 608461 | 474 | 960899 | 93 | 647562 | 567 | 352438 | 3 |
| 58 | 608745 | 473 | 960843 | 94 | 647903 | 567 | 352097 | 2 |
| 59 | 609029 | 473 | 960786 | 94 | 648243 | 567 | 351757 | 1 |
| 60 | 609313 | 473 | 960730 | 94 | 648583 | 566 | 351417 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

66 Degrees.

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·609313 | 473 | 9·960730 | 94 | 9·648583 | 566 | 10·351417 | 60 |
| 1 | 609597 | 472 | 960674 | 94 | 648923 | 566 | 351077 | 59 |
| 2 | 609880 | 472 | 960618 | 94 | 649263 | 566 | 350737 | 58 |
| 3 | 610164 | 472 | 960561 | 94 | 649602 | 566 | 350398 | 57 |
| 4 | 610447 | 471 | 960505 | 94 | 649942 | 565 | 350058 | 56 |
| 5 | 610729 | 471 | 960448 | 94 | 650281 | 565 | 349719 | 55 |
| 6 | 611012 | 470 | 960392 | 94 | 650620 | 565 | 349380. | 54 |
| 7 | 611294 | 470 | 960335 | 94 | 650959 | 564 | 349041 | 53 |
| 8 | 611576 | 470 | 960279 | 94 | 651297 | 564 | 348703 | 52 |
| 9 | 611858 | 469 | 960222 | 94 | 651636 | 564 | 348364 | 51 |
| 10 | 612140 | 469 | 960165 | 94 | 651974 | 563 | 348026 | 50 |
| 11 | 9·612421 | 469 | 9·960109 | 95 | 9·652312 | 563 | 10·347688 | 49 |
| 12 | 612702 | 468 | 960052 | 95 | 652650 | 563 | 347350 | 48 |
| 13 | 612983 | 468 | 959995 | 95 | 652988 | 563 | 347012 | 47 |
| 14 | 613264 | 467 | 959938 | 95 | 653326 | 562 | 346674 | 46 |
| 15 | 613545 | 467 | 959882 | 95 | 653663 | 562 | 346337 | 45 |
| 16 | 613825 | 467 | 959825 | 95 | 654000 | 562 | 346000 | 44 |
| 17 | 614105 | 466 | 959768 | 95 | 654337 | 561 | 345663 | 43 |
| 18 | 614385 | 466 | 959711 | 95 | 654674 | 561 | 345326 | 42 |
| 19 | 614665 | 466 | 959654 | 95 | 655011 | 561 | 344989 | 41 |
| 20 | 614944 | 465 | 959596 | 95 | 655348 | 561 | 344652 | 40 |
| 21 | 9·615223 | 465 | 9·959539 | 95 | 9·655684 | 560 | 10·344316 | 39 |
| 22 | 615502 | 465 | 959482 | 95 | 656020 | 560 | 343980 | 38 |
| 23 | 615781 | 464 | 959425 | 95 | 656356 | 560 | 343644 | 37 |
| 24 | 616060 | 464 | 959368 | 95 | 656692 | 559 | 343308 | 36 |
| 25 | 616338 | 464 | 959310 | 96 | 657028 | 559 | 342972 | 35 |
| 26 | 616616 | 463 | 959253 | 96 | 657364 | 559 | 342636 | 34 |
| 27 | 616894 | 463 | 959195 | 96 | 657699 | 559 | 342301 | 33 |
| 28 | 617172 | 462 | 959138 | 96 | 658034 | 558 | 341966 | 32 |
| 29 | 617450 | 462 | 959081 | 96 | 658369 | 558 | 341631 | 31 |
| 30 | 617727 | 462 | 959023 | 96 | 658704 | 558 | 341296 | 30 |
| 31 | 9·618004 | 461 | 9·958965 | 96 | 9·659039 | 558 | 10·340961 | 29 |
| 32 | 618281 | 461 | 958908 | 96 | 659373 | 557 | 340627 | 28 |
| 33 | 618558 | 461 | 958850 | 96 | 659708 | 557 | 340292 | 27 |
| 34 | 618834 | 460 | 958792 | 96 | 660042 | 557 | 339958 | 26 |
| 35 | 619110 | 460 | 958734 | 96 | 660376 | 557 | 339624 | 25 |
| 36 | 619386 | 460 | 958677 | 96 | 660710 | 556 | 339290 | 24 |
| 37 | 619662 | 459 | 958619 | 96 | 661043 | 556 | 338957 | 23 |
| 38 | 619938 | 459 | 958561 | 96 | 661377 | 556 | 338623 | 22 |
| 39 | 620213 | 459 | 958503 | 97 | 661710 | 555 | 338290 | 21 |
| 40 | 620488 | 458 | 958445 | 97 | 662043 | 555 | 337957 | 20 |
| 41 | 9·620763 | 458 | 9·958387 | 97 | 9·662376 | 555 | 10·337624 | 19 |
| 42 | 621038 | 457 | 958329 | 97 | 662709 | 554 | 337291 | 18 |
| 43 | 621313 | 457 | 958271 | 97 | 663042 | 554 | 336958 | 17 |
| 44 | 621587 | 457 | 958213 | 97 | 663375 | 554 | 336625 | 16 |
| 45 | 621861 | 456 | 958154 | 97 | 663707 | 554 | 336293 | 15 |
| 46 | 622135 | 456 | 958096 | 97 | 664039 | 553 | 335961 | 14 |
| 47 | 622409 | 456 | 958038 | 97 | 664371 | 553 | 335629 | 13 |
| 48 | 622682 | 455 | 957979 | 97 | 664703 | 553 | 335297 | 12 |
| 49 | 622956 | 455 | 957921 | 97 | 665035 | 553 | 334965 | 11 |
| 50 | 623229 | 455 | 957863 | 97 | 665366 | 552 | 334634 | 10 |
| 51 | 9·623502 | 454 | 9·957804 | 97 | 9·665697 | 552 | 10·334303 | 9 |
| 52 | 623774 | 454 | 957746 | 98 | 666029 | 552 | 333971 | 8 |
| 53 | 624047 | 454 | 957687 | 98 | 666360 | 551 | 333640 | 7 |
| 54 | 624319 | 453 | 957628 | 98 | 666691 | 551 | 333309 | 6 |
| 55 | 624591 | 453 | 957570 | 98 | 667021 | 551 | 332979 | 5 |
| 56 | 624863 | 453 | 957511 | 98 | 667352 | 551 | 332648 | 4 |
| 57 | 625135 | 452 | 957452 | 98 | 667682 | 550 | 332318 | 3 |
| 58 | 625406 | 452 | 957393 | 98 | 668013 | 550 | 331987 | 2 |
| 59 | 625677 | 452 | 957335 | 98 | 668343 | 550 | 331657 | 1 |
| 60 | 625948 | 451 | 957276 | 98 | 668672 | 550 | 331328 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·625948 | 451 | 9·957276 | 98 | 9·668673 | 550 | 10·331327 | 60 |
| 1 | 626219 | 451 | 957217 | 98 | 669002 | 549 | 330998 | 59 |
| 2 | 626490 | 451 | 957158 | 98 | 669332 | 549 | 330668 | 58 |
| 3 | 626760 | 450 | 957099 | 98 | 669661 | 549 | 330339 | 57 |
| 4 | 627030 | 450 | 957040 | 98 | 669991 | 548 | 330009 | 56 |
| 5 | 627300 | 450 | 956981 | 98 | 670320 | 548 | 329680 | 55 |
| 6 | 627570 | 449 | 956921 | 99 | 670649 | 548 | 329351 | 54 |
| 7 | 627840 | 449 | 956862 | 99 | 670977 | 548 | 329023 | 53 |
| 8 | 628109 | 449 | 956803 | 99 | 671306 | 547 | 328694 | 52 |
| 9 | 628378 | 448 | 956744 | 99 | 671634 | 547 | 328366 | 51 |
| 10 | 628647 | 448 | 956684 | 99 | 671963 | 547 | 328037 | 50 |
| 11 | 9·628916 | 447 | 9·956625 | 99 | 9·672291 | 547 | 10·327709 | 49 |
| 12 | 629185 | 447 | 956566 | 99 | 672619 | 546 | 327381 | 48 |
| 13 | 629453 | 447 | 956506 | 99 | 672947 | 546 | 327053 | 47 |
| 14 | 629721 | 446 | 956447 | 99 | 673274 | 546 | 326726 | 46 |
| 15 | 629989 | 446 | 956387 | 99 | 673602 | 546 | 326398 | 45 |
| 16 | 630257 | 446 | 956327 | 99 | 673929 | 545 | 326071 | 44 |
| 17 | 630524 | 446 | 956268 | 99 | 674257 | 545 | 325743 | 43 |
| 18 | 630792 | 445 | 956208 | 100 | 674584 | 545 | 325416 | 42 |
| 19 | 631059 | 445 | 956148 | 100 | 674910 | 544 | 325090 | 41 |
| 20 | 631326 | 445 | 956089 | 100 | 675237 | 544 | 324763 | 40 |
| 21 | 9·631593 | 444 | 9·956029 | 100 | 9·675564 | 544 | 10·324436 | 39 |
| 22 | 631859 | 444 | 955969 | 100 | 675890 | 544 | 324110 | 38 |
| 23 | 632125 | 444 | 955909 | 100 | 676216 | 543 | 323784 | 37 |
| 24 | 632392 | 443 | 955849 | 100 | 676543 | 543 | 323457 | 36 |
| 25 | 632658 | 443 | 955789 | 100 | 676869 | 543 | 323131 | 35 |
| 26 | 632923 | 443 | 955729 | 100 | 677194 | 543 | 322806 | 34 |
| 27 | 633189 | 442 | 955669 | 100 | 677520 | 542 | 322480 | 33 |
| 28 | 633454 | 442 | 955609 | 100 | 677846 | 542 | 322154 | 32 |
| 29 | 633719 | 442 | 955548 | 100 | 678171 | 542 | 321829 | 31 |
| 30 | 633984 | 441 | 955488 | 100 | 678496 | 542 | 321504 | 30 |
| 31 | 9·634249 | 441 | 9·955428 | 101 | 9·678821 | 541 | 10·321179 | 29 |
| 32 | 634514 | 440 | 955368 | 101 | 679146 | 541 | 320854 | 28 |
| 33 | 634778 | 440 | 955307 | 101 | 679471 | 541 | 320529 | 27 |
| 34 | 635042 | 440 | 955247 | 101 | 679795 | 541 | 320205 | 26 |
| 35 | 635306 | 439 | 955186 | 101 | 680120 | 540 | 319880 | 25 |
| 36 | 635570 | 439 | 955126 | 101 | 680444 | 540 | 319556 | 24 |
| 37 | 635834 | 439 | 955065 | 101 | 680768 | 540 | 319232 | 23 |
| 38 | 636097 | 438 | 955005 | 101 | 681092 | 540 | 318908 | 22 |
| 39 | 636360 | 438 | 954944 | 101 | 681416 | 539 | 318584 | 21 |
| 40 | 636623 | 438 | 954883 | 101 | 681740 | 539 | 318260 | 20 |
| 41 | 9·636886 | 437 | 9·954823 | 101 | 9·682063 | 539 | 10·317937 | 19 |
| 42 | 637148 | 437 | 954762 | 101 | 682387 | 539 | 317613 | 18 |
| 43 | 637411 | 437 | 954701 | 101 | 682710 | 538 | 317290 | 17 |
| 44 | 637673 | 437 | 954640 | 101 | 683033 | 538 | 316967 | 16 |
| 45 | 637935 | 436 | 954579 | 101 | 683356 | 538 | 316644 | 15 |
| 46 | 638197 | 436 | 954518 | 102 | 683679 | 538 | 316321 | 14 |
| 47 | 638458 | 436 | 954457 | 102 | 684001 | 537 | 315999 | 13 |
| 48 | 638720 | 435 | 954396 | 102 | 684324 | 537 | 315676 | 12 |
| 49 | 638981 | 435 | 954335 | 102 | 684646 | 537 | 315354 | 11 |
| 50 | 639242 | 435 | 954274 | 102 | 684968 | 537 | 315032 | 10 |
| 51 | 9·639503 | 434 | 9·954213 | 102 | 9·685290 | 536 | 10·314710 | 9 |
| 52 | 639764 | 434 | 954152 | 102 | 685612 | 536 | 314388 | 8 |
| 53 | 640024 | 434 | 954090 | 102 | 685934 | 536 | 314066 | 7 |
| 54 | 640284 | 433 | 954029 | 102 | 686255 | 536 | 313745 | 6 |
| 55 | 640544 | 433 | 953968 | 102 | 686577 | 535 | 313423 | 5 |
| 56 | 640804 | 433 | 953906 | 102 | 686898 | 535 | 313102 | 4 |
| 57 | 641064 | 432 | 953845 | 102 | 687219 | 535 | 312781 | 3 |
| 58 | 641324 | 432 | 953783 | 102 | 687540 | 535 | 312460 | 2 |
| 59 | 641584 | 432 | 953722 | 103 | 687861 | 534 | 312139 | 1 |
| 60 | 641842 | 431 | 953660 | 103 | 688182 | 534 | 311818 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·641842 | 431 | 9·953660 | 103 | 9·688182 | 534 | 10·311818 | 60 |
| 1 | 642101 | 431 | 953599 | 103 | 688502 | 534 | 311498 | 59 |
| 2 | 642360 | 421 | 953537 | 103 | 688823 | 534 | 311177 | 58 |
| 3 | 642618 | 430 | 953475 | 103 | 689143 | 533 | 310857 | 57 |
| 4 | 642877 | 430 | 953413 | 103 | 689463 | 533 | 310537 | 56 |
| 5 | 643135 | 430 | 953352 | 103 | 689783 | 533 | 310217 | 55 |
| 6 | 643393 | 430 | 953290 | 103 | 690103 | 533 | 309897 | 54 |
| 7 | 643650 | 429 | 953228 | 103 | 690423 | 533 | 309577 | 53 |
| 8 | 643908 | 429 | 953166 | 103 | 690742 | 532 | 309258 | 52 |
| 9 | 644165 | 429 | 953104 | 103 | 691062 | 532 | 308938 | 51 |
| 10 | 644423 | 428 | 953042 | 103 | 691381 | 532 | 308619 | 50 |
| 11 | 9·644680 | 428 | 9·952980 | 104 | 9·691700 | 531 | 10·308300 | 49 |
| 12 | 644936 | 428 | 952918 | 104 | 692019 | 531 | 307981 | 48 |
| 13 | 645193 | 427 | 952855 | 104 | 692338 | 531 | 307662 | 47 |
| 14 | 645450 | 427 | 952793 | 104 | 692656 | 531 | 307344 | 46 |
| 15 | 645706 | 427 | 952731 | 104 | 692975 | 531 | 307025 | 45 |
| 16 | 645962 | 426 | 952669 | 104 | 693293 | 530 | 306707 | 44 |
| 17 | 646218 | 426 | 952606 | 104 | 693612 | 530 | 306388 | 43 |
| 18 | 646474 | 426 | 952544 | 104 | 693930 | 530 | 306070 | 42 |
| 19 | 646729 | 425 | 952481 | 104 | 694248 | 530 | 305752 | 41 |
| 20 | 646984 | 425 | 952419 | 104 | 694566 | 529 | 305434 | 40 |
| 21 | 9·647240 | 425 | 9·952356 | 104 | 9·694883 | 529 | 10·305117 | 39 |
| 22 | 647494 | 424 | 952294 | 104 | 695201 | 529 | 304799 | 38 |
| 23 | 647749 | 424 | 952231 | 104 | 695518 | 529 | 304482 | 37 |
| 24 | 648004 | 424 | 952168 | 105 | 695836 | 529 | 304164 | 36 |
| 25 | 648258 | 424 | 952106 | 105 | 696153 | 528 | 303847 | 35 |
| 26 | 648512 | 423 | 952043 | 105 | 696470 | 528 | 303530 | 34 |
| 27 | 648766 | 423 | 951980 | 105 | 696787 | 528 | 303213 | 33 |
| 28 | 649020 | 423 | 951917 | 105 | 697103 | 528 | 302897 | 32 |
| 29 | 649274 | 422 | 951854 | 105 | 697420 | 527 | 302580 | 31 |
| 30 | 649527 | 422 | 951791 | 105 | 697736 | 527 | 302264 | 30 |
| 31 | 9·649781 | 422 | 9·951728 | 105 | 9·698053 | 527 | 10·301947 | 29 |
| 32 | 650034 | 422 | 951665 | 105 | 698369 | 527 | 301631 | 28 |
| 33 | 650287 | 421 | 951602 | 105 | 698685 | 526 | 301315 | 27 |
| 34 | 650539 | 421 | 951539 | 105 | 699001 | 526 | 300999 | 26 |
| 35 | 650792 | 421 | 951476 | 105 | 699316 | 526 | 300684 | 25 |
| 36 | 651044 | 420 | 951413 | 105 | 699632 | 526 | 300368 | 24 |
| 37 | 651297 | 420 | 951349 | 106 | 699947 | 526 | 300053 | 23 |
| 38 | 651549 | 420 | 951286 | 106 | 700263 | 525 | 299737 | 22 |
| 39 | 651800 | 419 | 951222 | 106 | 700578 | 525 | 299422 | 21 |
| 40 | 652052 | 419 | 951159 | 106 | 700893 | 525 | 299107 | 20 |
| 41 | 9·652304 | 419 | 9·951096 | 106 | 9·701208 | 524 | 10·298792 | 19 |
| 42 | 652555 | 418 | 951032 | 106 | 701523 | 524 | 298477 | 18 |
| 43 | 652806 | 418 | 950968 | 106 | 701837 | 524 | 298163 | 17 |
| 44 | 653057 | 418 | 950905 | 106 | 702152 | 524 | 297848 | 16 |
| 45 | 653308 | 418 | 950841 | 106 | 702466 | 524 | 297534 | 15 |
| 46 | 653558 | 417 | 950778 | 106 | 702780 | 523 | 297220 | 14 |
| 47 | 653808 | 417 | 950714 | 106 | 703095 | 523 | 296905 | 13 |
| 48 | 654059 | 417 | 950650 | 106 | 703400 | 523 | 296591 | 12 |
| 49 | 654309 | 416 | 950586 | 106 | 703723 | 523 | 296277 | 11 |
| 50 | 654558 | 416 | 950522 | 107 | 704036 | 522 | 295964 | 10 |
| 51 | 654808 | 416 | 9·950458 | 107 | 9·704350 | 522 | 10·295650 | 9 |
| 52 | 655058 | 416 | 950394 | 107 | 704663 | 522 | 295337 | 8 |
| 53 | 655307 | 415 | 950330 | 107 | 704977 | 522 | 295023 | 7 |
| 54 | 655556 | 415 | 950266 | 107 | 705290 | 522 | 294710 | 6 |
| 55 | 655805 | 415 | 950202 | 107 | 705603 | 521 | 294397 | 5 |
| 56 | 656054 | 414 | 950138 | 107 | 705916 | 521 | 294084 | 4 |
| 57 | 656302 | 414 | 950074 | 107 | 706228 | 521 | 293772 | 3 |
| 58 | 656551 | 414 | 950010 | 107 | 706541 | 521 | 293459 | 2 |
| 59 | 656799 | 413 | 949945 | 107 | 706854 | 521 | 293146 | 1 |
| 60 | 657047 | 413 | 949881 | 107 | 707166 | 520 | 292834 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

63 Degrees.

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·657047 | 413 | 9·949881 | 107 | 9·707166 | 520 | 10·292834 | 60 |
| 1 | 657295 | 413 | 949816 | 107 | 707478 | 520 | 292522 | 59 |
| 2 | 657542 | 412 | 949752 | 107 | 707790 | 520 | 292210 | 58 |
| 3 | 657790 | 412 | 949688 | 108 | 708102 | 520 | 291898 | 57 |
| 4 | 658037 | 412 | 949623 | 108 | 708414 | 519 | 291586 | 56 |
| 5 | 658284 | 412 | 949558 | 108 | 708726 | 519 | 291274 | 55 |
| 6 | 658531 | 411 | 949494 | 108 | 709037 | 519 | 290963 | 54 |
| 7 | 658778 | 411 | 949429 | 108 | 709349 | 519 | 290651 | 53 |
| 8 | 659025 | 411 | 949364 | 108 | 709660 | 519 | 290340 | 52 |
| 9 | 659271 | 410 | 949300 | 108 | 709971 | 518 | 290029 | 51 |
| 10 | 659517 | 410 | 949235 | 108 | 710282 | 518 | 289718 | 50 |
| 11 | 9·659763 | 410 | 9·949170 | 108 | 9·710593 | 518 | 10·289407 | 49 |
| 12 | 660009 | 409 | 949105 | 108 | 710904 | 518 | 289096 | 48 |
| 13 | 660255 | 409 | 949040 | 108 | 711215 | 518 | 288785 | 47 |
| 14 | 660501 | 409 | 948975 | 108 | 711525 | 517 | 288475 | 46 |
| 15 | 660746 | 409 | 948910 | 108 | 711836 | 517 | 288164 | 45 |
| 16 | 660991 | 408 | 948845 | 108 | 712146 | 517 | 287854 | 44 |
| 17 | 661236 | 408 | 948780 | 109 | 712456 | 517 | 287544 | 43 |
| 18 | 661481 | 408 | 948715 | 109 | 712766 | 516 | 287234 | 42 |
| 19 | 661726 | 407 | 948650 | 109 | 713076 | 516 | 286924 | 41 |
| 20 | 661970 | 407 | 948584 | 109 | 713386 | 516 | 286614 | 40 |
| 21 | 9·662214 | 407 | 9·948519 | 109 | 9·713696 | 516 | 10·286304 | 39 |
| 22 | 662459 | 407 | 948454 | 109 | 714005 | 516 | 285995 | 38 |
| 23 | 662703 | 406 | 948388 | 109 | 714314 | 515 | 285686 | 37 |
| 24 | 662946 | 406 | 948323 | 109 | 714624 | 515 | 285376 | 36 |
| 25 | 663190 | 406 | 948257 | 109 | 714933 | 515 | 285067 | 35 |
| 26 | 663433 | 405 | 948192 | 109 | 715242 | 515 | 284758 | 34 |
| 27 | 663677 | 405 | 948126 | 109 | 715551 | 514 | 284449 | 33 |
| 28 | 663920 | 405 | 948060 | 109 | 715860 | 514 | 284140 | 32 |
| 29 | 664163 | 405 | 947995 | 110 | 716168 | 514 | 283832 | 31 |
| 30 | 664406 | 404 | 947929 | 110 | 716477 | 514 | 283523 | 30 |
| 31 | 9·664648 | 404 | 9·947863 | 110 | 9·716785 | 514 | 10·283215 | 29 |
| 32 | 664891 | 404 | 947797 | 110 | 717093 | 513 | 282907 | 28 |
| 33 | 665133 | 403 | 947731 | 110 | 717401 | 513 | 282599 | 27 |
| 34 | 665375 | 403 | 947665 | 110 | 717709 | 513 | 282291 | 26 |
| 35 | 665617 | 403 | 947600 | 110 | 718017 | 513 | 281983 | 25 |
| 36 | 665859 | 402 | 947533 | 110 | 718325 | 513 | 281675 | 24 |
| 37 | 666100 | 402 | 947467 | 110 | 718633 | 512 | 281367 | 23 |
| 38 | 666342 | 402 | 947401 | 110 | 718940 | 512 | 281060 | 22 |
| 39 | 666583 | 402 | 947335 | 110 | 719248 | 512 | 280752 | 21 |
| 40 | 666824 | 401 | 947269 | 110 | 719555 | 512 | 280445 | 20 |
| 41 | 9·667065 | 401 | 9·947203 | 110 | 8·719862 | 512 | 10·280138 | 19 |
| 42 | 667305 | 401 | 847136 | 111 | 720169 | 511 | 279831 | 18 |
| 43 | 667546 | 401 | 947070 | 111 | 720476 | 511 | 279524 | 17 |
| 44 | 667786 | 400 | 947004 | 111 | 720783 | 511 | 279217 | 16 |
| 45 | 668027 | 400 | 946937 | 111 | 721089 | 511 | 278911 | 15 |
| 46 | 668267 | 400 | 946871 | 111 | 721396 | 511 | 278604 | 14 |
| 47 | 668506 | 399 | 946804 | 111 | 721702 | 510 | 278298 | 13 |
| 48 | 668746 | 399 | 946738 | 111 | 722009 | 510 | 277991 | 12 |
| 49 | 668986 | 399 | 946671 | 111 | 722315 | 510 | 277685 | 11 |
| 50 | 669225 | 399 | 946604 | 111 | 722621 | 510 | 277379 | 10 |
| 51 | 9·669464 | 398 | 9·946538 | 111 | 9·722927 | 510 | 10·277073 | 9 |
| 52 | 669703 | 398 | 946471 | 111 | 723232 | 509 | 276768 | 8 |
| 53 | 669942 | 398 | 946404 | 111 | 723538 | 509 | 276462 | 7 |
| 54 | 670181 | 397 | 946337 | 111 | 723844 | 509 | 276156 | 6 |
| 55 | 670419 | 397 | 946270 | 112 | 724149 | 509 | 275851 | 5 |
| 56 | 670658 | 397 | 946203 | 112 | 724454 | 509 | 275546 | 4 |
| 57 | 670896 | 397 | 946136 | 112 | 724759 | 508 | 275241 | 3 |
| 58 | 671134 | 396 | 946069 | 112 | 725065 | 508 | 274935 | 2 |
| 59 | 671372 | 396 | 946002 | 112 | 725369 | 508 | 274631 | 1 |
| 60 | 671609 | 396 | 945935 | 112 | 725674 | 508 | 274326 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

62 Degrees.

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·671609 | 396 | 9·945935 | 112 | 9·725674 | 508 | 10·274326 | 60 |
| 1 | 671847 | 395 | 945868 | 112 | 725979 | 508 | 274021 | 59 |
| 2 | 672084 | 395 | 945800 | 112 | 726284 | 507 | 273716 | 58 |
| 3 | 672321 | 395 | 945733 | 112 | 726588 | 507 | 273412 | 57 |
| 4 | 672558 | 395 | 945666 | 112 | 726892 | 507 | 273108 | 56 |
| 5 | 672795 | 394 | 945598 | 112 | 727197 | 507 | 272803 | 55 |
| 6 | 673032 | 394 | 945531 | 112 | 727501 | 507 | 272499 | 54 |
| 7 | 673268 | 394 | 945464 | 113 | 727805 | 506 | 272195 | 53 |
| 8 | 673505 | 394 | 945396 | 113 | 728109 | 506 | 271891 | 52 |
| 9 | 673741 | 393 | 945328 | 113 | 728412 | 506 | 271588 | 51 |
| 10 | 673977 | 393 | 945261 | 113 | 728716 | 506 | 271284 | 50 |
| 11 | 9·674213 | 393 | 9·945193 | 113 | 9·729020 | 506 | 10·270980 | 49 |
| 12 | 674448 | 392 | 945125 | 113 | 729323 | 505 | 270677 | 48 |
| 13 | 674684 | 392 | 945058 | 113 | 729626 | 505 | 270374 | 47 |
| 14 | 674919 | 392 | 944990 | 113 | 729929 | 505 | 270071 | 46 |
| 15 | 675155 | 392 | 944922 | 113 | 730233 | 505 | 269767 | 45 |
| 16 | 675390 | 391 | 944854 | 113 | 730535 | 505 | 269465 | 44 |
| 17 | 675624 | 391 | 944786 | 113 | 730838 | 504 | 269162 | 43 |
| 18 | 675859 | 391 | 944718 | 113 | 731141 | 504 | 268859 | 42 |
| 19 | 676094 | 391 | 944650 | 113 | 731444 | 504 | 268556 | 41 |
| 20 | 676328 | 390 | 944582 | 114 | 731746 | 504 | 268254 | 40 |
| 21 | 9·676562 | 390 | 9·944514 | 114 | 9·732048 | 504 | 10·267952 | 39 |
| 22 | 676796 | 390 | 944446 | 114 | 732351 | 503 | 267649 | 38 |
| 23 | 677030 | 390 | 944377 | 114 | 732653 | 503 | 267347 | 37 |
| 24 | 677264 | 389 | 944309 | 114 | 732955 | 503 | 267045 | 36 |
| 25 | 677498 | 389 | 944241 | 114 | 733257 | 503 | 266743 | 35 |
| 26 | 677731 | 389 | 944172 | 114 | 733558 | 503 | 266442 | 34 |
| 27 | 677964 | 388 | 944104 | 114 | 733860 | 502 | 266140 | 33 |
| 28 | 678197 | 388 | 944036 | 114 | 734162 | 502 | 265838 | 32 |
| 29 | 678430 | 388 | 943967 | 114 | 734463 | 502 | 265537 | 31 |
| 30 | 678663 | 388 | 943899 | 114 | 734764 | 502 | 265236 | 30 |
| 31 | 9·678895 | 387 | 9·943830 | 114 | 9·735066 | 402 | 10·264934 | 29 |
| 32 | 679128 | 387 | 943761 | 114 | 735367 | 502 | 264633 | 28 |
| 33 | 679360 | 387 | 943693 | 115 | 735668 | 501 | 264332 | 27 |
| 34 | 679592 | 387 | 943624 | 115 | 735969 | 501 | 264031 | 26 |
| 35 | 679824 | 386 | 943555 | 115 | 736269 | 501 | 263731 | 25 |
| 36 | 680056 | 386 | 943486 | 115 | 736570 | 501 | 263430 | 24 |
| 37 | 680288 | 386 | 943417 | 115 | 736871 | 501 | 263129 | 23 |
| 38 | 680519 | 385 | 943348 | 115 | 737171 | 500 | 262829 | 22 |
| 39 | 680750 | 385 | 943279 | 115 | 737471 | 500 | 262529 | 21 |
| 40 | 680982 | 385 | 943210 | 115 | 737771 | 500 | 262229 | 20 |
| 41 | 9·681213 | 385 | 9·943141 | 115 | 9·738071 | 500 | 10·261929 | 19 |
| 42 | 681443 | 384 | 943072 | 115 | 738371 | 500 | 261629 | 18 |
| 43 | 681674 | 384 | 943003 | 115 | 738671 | 499 | 261329 | 17 |
| 44 | 681905 | 384 | 942934 | 115 | 738971 | 499 | 261029 | 16 |
| 45 | 682135 | 384 | 942864 | 115 | 739271 | 499 | 260729 | 15 |
| 46 | 682365 | 383 | 942795 | 116 | 739570 | 499 | 260430 | 14 |
| 47 | 682595 | 383 | 942726 | 116 | 739870 | 499 | 260130 | 13 |
| 48 | 682825 | 383 | 942656 | 116 | 740169 | 499 | 259831 | 12 |
| 49 | 683055 | 383 | 942587 | 116 | 740468 | 498 | 259532 | 11 |
| 50 | 683284 | 382 | 942517 | 116 | 740767 | 498 | 259233 | 10 |
| 51 | 9·683514 | 382 | 9·942448 | 116 | 9·741066 | 498 | 10·258934 | 9 |
| 52 | 683743 | 382 | 942378 | 116 | 741365 | 498 | 258635 | 8 |
| 53 | 683972 | 382 | 942308 | 116 | 741664 | 498 | 258336 | 7 |
| 54 | 684201 | 381 | 942239 | 116 | 741962 | 497 | 258038 | 6 |
| 55 | 684430 | 381 | 942169 | 116 | 742261 | 497 | 257739 | 5 |
| 56 | 684658 | 381 | 942099 | 116 | 742559 | 497 | 257441 | 4 |
| 57 | 684887 | 380 | 942029 | 116 | 742858 | 497 | 257142 | 3 |
| 58 | 685115 | 380 | 941959 | 116 | 743156 | 497 | 256844 | 2 |
| 59 | 685343 | 380 | 941889 | 117 | 743454 | 497 | 256546 | 1 |
| 60 | 685571 | 380 | 941819 | 117 | 743752 | 496 | 256248 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·685571 | 380 | 9·941819 | 117 | 9·743752 | 496 | 10·256248 | 60 |
| 1 | 685799 | 379 | 941749 | 117 | 744050 | 496 | 255950 | 59 |
| 2 | 686027 | 379 | 941679 | 117 | 744348 | 496 | 255652 | 58 |
| 3 | 686254 | 379 | 941609 | 117 | 744645 | 496 | 255355 | 57 |
| 4 | 686482 | 379 | 941539 | 117 | 744943 | 496 | 255057 | 56 |
| 5 | 686709 | 378 | 941469 | 117 | 745240 | 496 | 254760 | 55 |
| 6 | 686936 | 378 | 941398 | 117 | 745538 | 495 | 254462 | 54 |
| 7 | 687163 | 378 | 941328 | 117 | 745835 | 495 | 254165 | 53 |
| 8 | 687389 | 378 | 941258 | 117 | 746132 | 495 | 253868 | 52 |
| 9 | 687616 | 377 | 941187 | 117 | 746429 | 495 | 253571 | 51 |
| 10 | 687843 | 377 | 941117 | 117 | 746726 | 495 | 253274 | 50 |
| 11 | 9·688069 | 377 | 9·941046 | 118 | 9·747023 | 494 | 10·252977 | 49 |
| 12 | 688295 | 377 | 940975 | 118 | 747319 | 494 | 252681 | 48 |
| 13 | 688521 | 376 | 940905 | 118 | 747616 | 494 | 252384 | 47 |
| 14 | 688747 | 376 | 940834 | 118 | 747913 | 494 | 252087 | 46 |
| 15 | 688972 | 376 | 940763 | 118 | 748209 | 494 | 251791 | 45 |
| 16 | 689198 | 376 | 940693 | 118 | 748505 | 493 | 251495 | 44 |
| 17 | 689423 | 375 | 940622 | 118 | 748801 | 493 | 251199 | 43 |
| 18 | 689648 | 375 | 940551 | 118 | 749097 | 493 | 250903 | 42 |
| 19 | 689873 | 375 | 940480 | 118 | 749393 | 493 | 250607 | 41 |
| 20 | 690098 | 375 | 940409 | 118 | 749689 | 493 | 250311 | 40 |
| 21 | 9·690323 | 374 | 9·940338 | 118 | 9·749985 | 493 | 10·250015 | 39 |
| 22 | 690548 | 374 | 940267 | 118 | 750281 | 492 | 249719 | 38 |
| 23 | 690772 | 374 | 940196 | 118 | 750576 | 492 | 249424 | 37 |
| 24 | 690996 | 374 | 940125 | 119 | 750872 | 492 | 249128 | 36 |
| 25 | 691220 | 373 | 940054 | 119 | 751167 | 492 | 248833 | 35 |
| 26 | 691444 | 373 | 939982 | 119 | 751462 | 492 | 248538 | 34 |
| 27 | 691668 | 373 | 939911 | 119 | 751757 | 492 | 248243 | 33 |
| 28 | 691892 | 373 | 939840 | 119 | 752052 | 491 | 247948 | 32 |
| 29 | 692115 | 372 | 939768 | 119 | 752347 | 491 | 247653 | 31 |
| 30 | 692339 | 372 | 939697 | 119 | 752642 | 491 | 247358 | 30 |
| 31 | 9·692562 | 372 | 9·939625 | 119 | 9·752937 | 491 | 10·247063 | 29 |
| 32 | 692785 | 371 | 939554 | 119 | 753231 | 491 | 246769 | 28 |
| 33 | 693008 | 371 | 939482 | 119 | 753526 | 491 | 246474 | 27 |
| 34 | 693231 | 371 | 939410 | 119 | 753820 | 490 | 246180 | 26 |
| 35 | 693453 | 371 | 939339 | 119 | 754115 | 490 | 245885 | 25 |
| 36 | 693676 | 370 | 939267 | 120 | 754409 | 490 | 245591 | 24 |
| 37 | 693898 | 370 | 939195 | 120 | 754703 | 490 | 245297 | 23 |
| 38 | 694120 | 370 | 939123 | 120 | 754997 | 490 | 245003 | 22 |
| 39 | 694342 | 370 | 939052 | 120 | 755291 | 490 | 244709 | 21 |
| 40 | 694564 | 369 | 938980 | 120 | 755585 | 489 | 244415 | 20 |
| 41 | 9·694786 | 369 | 9·938908 | 120 | 9·755878 | 489 | 10·244122 | 19 |
| 42 | 695007 | 369 | 938836 | 120 | 756172 | 489 | 243828 | 18 |
| 43 | 695229 | 369 | 938763 | 120 | 756465 | 489 | 243535 | 17 |
| 44 | 695450 | 368 | 938691 | 120 | 756759 | 489 | 243241 | 16 |
| 45 | 695671 | 368 | 938619 | 120 | 757052 | 489 | 242948 | 15 |
| 46 | 695892 | 368 | 938547 | 120 | 757345 | 488 | 242655 | 14 |
| 47 | 696113 | 368 | 938475 | 120 | 757638 | 488 | 242362 | 13 |
| 48 | 696334 | 367 | 938402 | 121 | 757931 | 488 | 242069 | 12 |
| 49 | 696554 | 367 | 938330 | 121 | 758224 | 488 | 241776 | 11 |
| 50 | 696775 | 367 | 938258 | 121 | 758517 | 488 | 241483 | 10 |
| 51 | 9·696995 | 367 | 9·938185 | 121 | 9·758810 | 488 | 10·241190 | 9 |
| 52 | 697215 | 366 | 938113 | 121 | 759102 | 487 | 240898 | 8 |
| 53 | 697435 | 366 | 938040 | 121 | 759395 | 487 | 240605 | 7 |
| 54 | 697654 | 366 | 937967 | 121 | 759687 | 487 | 240313 | 6 |
| 55 | 697874 | 366 | 937895 | 121 | 759979 | 487 | 240021 | 5 |
| 56 | 698094 | 365 | 937822 | 121 | 760272 | 487 | 239728 | 4 |
| 57 | 698313 | 365 | 937749 | 121 | 760564 | 487 | 239436 | 3 |
| 58 | 698532 | 365 | 937676 | 121 | 760856 | 486 | 239144 | 2 |
| 59 | 698751 | 365 | 937604 | 121 | 761148 | 486 | 238852 | 1 |
| 60 | 698970 | 364 | 937531 | 121 | 761439 | 486 | 238561 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

60 Degrees.

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·698970 | 364 | 9·937531 | 121 | 9·761439 | 486 | 10·238561 | 60 |
| 1 | 699189 | 364 | 937458 | 122 | 761731 | 486 | 238269 | 59 |
| 2 | 699407 | 364 | 937385 | 122 | 762023 | 486 | 237977 | 58 |
| 3 | 699626 | 364 | 937312 | 122 | 762314 | 486 | 237686 | 57 |
| 4 | 699844 | 363 | 937238 | 122 | 762606 | 485 | 237394 | 56 |
| 5 | 700062 | 363 | 937165 | 122 | 762897 | 485 | 237103 | 55 |
| 6 | 700280 | 363 | 937092 | 122 | 763188 | 485 | 236812 | 54 |
| 7 | 700498 | 363 | 937019 | 122 | 763479 | 485 | 236521 | 53 |
| 8 | 700716 | 363 | 936946 | 122 | 763770 | 485 | 236230 | 52 |
| 9 | 700933 | 362 | 936872 | 122 | 764061 | 485 | 235939 | 51 |
| 10 | 701151 | 362 | 936799 | 122 | 764352 | 484 | 235648 | 50 |
| 11 | 9·701368 | 362 | 9·936725 | 122 | 9·764643 | 484 | 10·235357 | 49 |
| 12 | 701585 | 362 | 936652 | 123 | 764933 | 484 | 235067 | 48 |
| 13 | 701802 | 361 | 936578 | 123 | 765224 | 484 | 234776 | 47 |
| 14 | 702019 | 361 | 936505 | 123 | 765514 | 484 | 234486 | 46 |
| 15 | 702236 | 361 | 936431 | 123 | 765805 | 484 | 234195 | 45 |
| 16 | 702452 | 361 | 936357 | 123 | 766095 | 484 | 233905 | 44 |
| 17 | 702669 | 360 | 936284 | 123 | 766385 | 483 | 233615 | 43 |
| 18 | 702885 | 360 | 936210 | 123 | 766675 | 483 | 233325 | 42 |
| 19 | 703101 | 360 | 936136 | 123 | 766965 | 483 | 233035 | 41 |
| 20 | 703317 | 360 | 936062 | 123 | 767255 | 483 | 232745 | 40 |
| 21 | 9·703533 | 359 | 9·935988 | 123 | 9·767545 | 483 | 10·232455 | 39 |
| 22 | 703749 | 359 | 935914 | 123 | 767834 | 483 | 232166 | 38 |
| 23 | 703964 | 359 | 935840 | 123 | 768124 | 482 | 231876 | 37 |
| 24 | 704179 | 359 | 935766 | 124 | 768413 | 482 | 231587 | 36 |
| 25 | 704395 | 359 | 935692 | 124 | 768703 | 482 | 231297 | 35 |
| 26 | 704610 | 358 | 935618 | 124 | 768992 | 482 | 231008 | 34 |
| 27 | 704825 | 358 | 935543 | 124 | 769281 | 482 | 230719 | 33 |
| 28 | 705040 | 358 | 935469 | 124 | 769570 | 482 | 230430 | 32 |
| 29 | 705254 | 358 | 935395 | 124 | 769860 | 481 | 230140 | 31 |
| 30 | 705469 | 357 | 935320 | 124 | 770148 | 481 | 229852 | 30 |
| 31 | 9·705683 | 357 | 9·935246 | 124 | 9·770437 | 481 | 10·229563 | 29 |
| 32 | 705898 | 357 | 935171 | 124 | 770726 | 481 | 229274 | 28 |
| 33 | 706112 | 357 | 935097 | 124 | 771015 | 481 | 228985 | 27 |
| 34 | 706326 | 356 | 935022 | 124 | 771303 | 481 | 228697 | 26 |
| 35 | 706539 | 356 | 934948 | 124 | 771592 | 481 | 228408 | 25 |
| 36 | 706753 | 356 | 934873 | 124 | 771880 | 480 | 228120 | 24 |
| 37 | 706967 | 356 | 934798 | 125 | 772168 | 480 | 227832 | 23 |
| 38 | 707180 | 355 | 934723 | 125 | 772457 | 480 | 227543 | 22 |
| 39 | 707393 | 355 | 934649 | 125 | 772745 | 480 | 227255 | 21 |
| 40 | 707606 | 355 | 934574 | 125 | 773033 | 480 | 226967 | 20 |
| 41 | 9·707819 | 355 | 9·934499 | 125 | 9·773321 | 480 | 10·226679 | 19 |
| 42 | 708032 | 354 | 934424 | 125 | 773608 | 479 | 226392 | 18 |
| 43 | 708245 | 354 | 934349 | 125 | 773896 | 479 | 226104 | 17 |
| 44 | 708458 | 354 | 934274 | 125 | 774184 | 479 | 225816 | 16 |
| 45 | 708670 | 354 | 934199 | 125 | 774471 | 479 | 225529 | 15 |
| 46 | 708882 | 353 | 934123 | 125 | 774759 | 479 | 225241 | 14 |
| 47 | 709094 | 353 | 934048 | 125 | 775046 | 479 | 224954 | 13 |
| 48 | 709306 | 353 | 933973 | 125 | 775333 | 479 | 224667 | 12 |
| 49 | 709518 | 353 | 933898 | 126 | 775621 | 478 | 224379 | 11 |
| 50 | 709730 | 353 | 933822 | 126 | 775908 | 478 | 224092 | 10 |
| 51 | 9·709941 | 352 | 9·933747 | 126 | 9·776195 | 478 | 10·223805 | 9 |
| 52 | 710153 | 352 | 933671 | 126 | 776482 | 478 | 223518 | 8 |
| 53 | 710364 | 352 | 933596 | 126 | 776769 | 478 | 223231 | 7 |
| 54 | 710575 | 352 | 933520 | 126 | 777055 | 478 | 222945 | 6 |
| 55 | 710786 | 351 | 933445 | 126 | 777342 | 478 | 222658 | 5 |
| 56 | 710997 | 351 | 933369 | 126 | 777628 | 477 | 222372 | 4 |
| 57 | 711208 | 351 | 933293 | 126 | 777915 | 477 | 222085 | 3 |
| 58 | 711419 | 351 | 933217 | 126 | 778201 | 477 | 221799 | 2 |
| 59 | 711629 | 350 | 933141 | 126 | 778487 | 477 | 221512 | 1 |
| 60 | 711839 | 350 | 933066 | 126 | 778774 | 477 | 221226 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·711839 | 350 | 9·933006 | 126 | 9·778774 | 477 | 10·221226 | 60 |
| 1 | 712050 | 350 | 932990 | 127 | 779060 | 477 | 220940 | 59 |
| 2 | 712260 | 350 | 932914 | 127 | 779346 | 476 | 220654 | 58 |
| 3 | 712469 | 349 | 932838 | 127 | 779632 | 476 | 220368 | 57 |
| 4 | 712679 | 349 | 932762 | 127 | 779918 | 476 | 220082 | 56 |
| 5 | 712889 | 349 | 932685 | 127 | 780203 | 476 | 219797 | 55 |
| 6 | 713098 | 349 | 932609 | 127 | 780489 | 476 | 219511 | 54 |
| 7 | 713308 | 349 | 932533 | 127 | 780775 | 476 | 219225 | 53 |
| 8 | 713517 | 348 | 932457 | 127 | 781060 | 476 | 218940 | 52 |
| 9 | 713726 | 348 | 932380 | 127 | 781346 | 475 | 218654 | 51 |
| 10 | 713935 | 348 | 932304 | 127 | 781631 | 475 | 218369 | 50 |
| 11 | 9·714144 | 348 | 9·932228 | 127 | 9·781916 | 475 | 10·218084 | 49 |
| 12 | 714352 | 347 | 932151 | 127 | 782201 | 475 | 217799 | 48 |
| 13 | 714561 | 347 | 932075 | 128 | 782486 | 475 | 217514 | 47 |
| 14 | 714769 | 347 | 931998 | 128 | 782771 | 475 | 217229 | 46 |
| 15 | 714978 | 347 | 931921 | 128 | 783056 | 475 | 216944 | 45 |
| 16 | 715186 | 347 | 931845 | 128 | 783341 | 475 | 216659 | 44 |
| 17 | 715394 | 346 | 931768 | 128 | 783626 | 474 | 216374 | 43 |
| 18 | 715602 | 346 | 931691 | 128 | 783910 | 474 | 216090 | 42 |
| 19 | 715809 | 346 | 931614 | 128 | 784195 | 474 | 215805 | 41 |
| 20 | 716017 | 346 | 931537 | 128 | 784479 | 474 | 215521 | 40 |
| 21 | 9·716224 | 345 | 9·931460 | 128 | 9·784764 | 474 | 10·215236 | 39 |
| 22 | 716432 | 345 | 931383 | 128 | 785048 | 474 | 214952 | 38 |
| 23 | 716639 | 345 | 931306 | 128 | 785332 | 473 | 214668 | 37 |
| 24 | 716846 | 345 | 931229 | 129 | 785616 | 473 | 214384 | 36 |
| 25 | 717053 | 345 | 931152 | 129 | 785900 | 473 | 214100 | 35 |
| 26 | 717259 | 344 | 931075 | 129 | 786184 | 473 | 213816 | 34 |
| 27 | 717466 | 344 | 930998 | 129 | 786468 | 473 | 213532 | 33 |
| 28 | 717673 | 344 | 930921 | 129 | 786752 | 473 | 213248 | 32 |
| 29 | 717879 | 344 | 930843 | 129 | 787036 | 473 | 212964 | 31 |
| 30 | 718085 | 343 | 930766 | 129 | 787319 | 472 | 212681 | 30 |
| 31 | 9·718291 | 343 | 9·930688 | 129 | 9·787603 | 472 | 10·212397 | 29 |
| 32 | 718497 | 343 | 930611 | 129 | 787886 | 472 | 212114 | 28 |
| 33 | 718703 | 343 | 930533 | 129 | 788170 | 472 | 211830 | 27 |
| 34 | 718909 | 343 | 930456 | 129 | 788453 | 472 | 211547 | 26 |
| 35 | 719114 | 342 | 930378 | 129 | 788736 | 472 | 211264 | 25 |
| 36 | 719320 | 342 | 930300 | 130 | 789019 | 472 | 210981 | 24 |
| 37 | 719525 | 342 | 930223 | 130 | 789302 | 471 | 210698 | 23 |
| 38 | 719730 | 342 | 930145 | 130 | 789585 | 471 | 210415 | 22 |
| 39 | 719935 | 341 | 930067 | 130 | 789868 | 471 | 210132 | 21 |
| 40 | 720140 | 341 | 929989 | 130 | 790151 | 471 | 209849 | 20 |
| 41 | 9·720345 | 341 | 9·929911 | 130 | 9·790433 | 471 | 10·209567 | 19 |
| 42 | 720549 | 341 | 929833 | 130 | 790716 | 471 | 209284 | 18 |
| 43 | 720754 | 340 | 929755 | 130 | 790999 | 471 | 209001 | 17 |
| 44 | 720958 | 340 | 929677 | 130 | 791281 | 471 | 208719 | 16 |
| 45 | 721162 | 340 | 929599 | 130 | 791563 | 470 | 208437 | 15 |
| 46 | 721366 | 340 | 929521 | 130 | 791846 | 470 | 208154 | 14 |
| 47 | 721570 | 340 | 929442 | 130 | 792128 | 470 | 207872 | 13 |
| 48 | 721774 | 339 | 929364 | 131 | 792410 | 470 | 207590 | 12 |
| 49 | 721978 | 339 | 929286 | 131 | 792692 | 470 | 207308 | 11 |
| 50 | 722181 | 339 | 929207 | 131 | 792974 | 470 | 207026 | 10 |
| 51 | 9·722385 | 339 | 9·929129 | 131 | 9·793256 | 470 | 10·206744 | 9 |
| 52 | 722588 | 339 | 929050 | 131 | 793538 | 469 | 206462 | 8 |
| 53 | 722791 | 338 | 928972 | 131 | 793819 | 469 | 206181 | 7 |
| 54 | 722994 | 338 | 928893 | 131 | 794101 | 469 | 205899 | 6 |
| 55 | 723197 | 338 | 928815 | 131 | 794383 | 469 | 205617 | 5 |
| 56 | 723400 | 338 | 928736 | 131 | 794664 | 469 | 205336 | 4 |
| 57 | 723603 | 337 | 928657 | 131 | 794945 | 469 | 205055 | 3 |
| 58 | 723805 | 337 | 928578 | 131 | 795227 | 469 | 204773 | 2 |
| 59 | 724007 | 337 | 928499 | 131 | 795508 | 468 | 204492 | 1 |
| 60 | 724210 | 337 | 928420 | 131 | 795789 | 468 | 204211 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·724210 | 337 | 9·928420 | 132 | 9·795789 | 468 | 10·204211 | 60 |
| 1 | 724412 | 337 | 928342 | 132 | 796070 | 468 | 203930 | 59 |
| 2 | 724614 | 336 | 928263 | 132 | 796351 | 468 | 203649 | 58 |
| 3 | 724816 | 336 | 928183 | 132 | 796632 | 468 | 203368 | 57 |
| 4 | 725017 | 336 | 928104 | 132 | 796913 | 468 | 203087 | 56 |
| 5 | 725219 | 336 | 928025 | 132 | 797194 | 468 | 202806 | 55 |
| 6 | 725420 | 335 | 927946 | 132 | 797475 | 468 | 202525 | 54 |
| 7 | 725622 | 335 | 927867 | 132 | 797755 | 468 | 202245 | 53 |
| 8 | 725823 | 335 | 927787 | 132 | 798036 | 467 | 201964 | 52 |
| 9 | 726024 | 335 | 927708 | 132 | 798316 | 467 | 201684 | 51 |
| 10 | 726225 | 335 | 927629 | 132 | 798596 | 467 | 201404 | 50 |
| 11 | 9·726426 | 334 | 9·927549 | 132 | 9·798877 | 467 | 10·201123 | 49 |
| 12 | 726626 | 334 | 927470 | 133 | 799157 | 467 | 200843 | 48 |
| 13 | 726827 | 334 | 927390 | 133 | 799437 | 467 | 200563 | 47 |
| 14 | 727027 | 334 | 927310 | 133 | 799717 | 467 | 200283 | 46 |
| 15 | 727228 | 334 | 927231 | 133 | 799997 | 466 | 200003 | 45 |
| 16 | 727428 | 333 | 927151 | 133 | 800277 | 466 | 199723 | 44 |
| 17 | 727628 | 333 | 927071 | 133 | 800557 | 466 | 199443 | 43 |
| 18 | 727828 | 333 | 926991 | 133 | 800836 | 466 | 199164 | 42 |
| 19 | 728027 | 333 | 926911 | 133 | 801116 | 466 | 198884 | 41 |
| 20 | 728227 | 333 | 926831 | 133 | 801396 | 466 | 198604 | 40 |
| 21 | 9·728427 | 332 | 9·926751 | 133 | 9·801675 | 466 | 10·198325 | 39 |
| 22 | 728626 | 332 | 926671 | 133 | 801955 | 466 | 198045 | 38 |
| 23 | 728825 | 332 | 926591 | 133 | 802234 | 465 | 197766 | 37 |
| 24 | 729024 | 332 | 926511 | 134 | 802513 | 465 | 197487 | 36 |
| 25 | 729223 | 331 | 926431 | 134 | 802792 | 465 | 197208 | 35 |
| 26 | 729422 | 331 | 926351 | 134 | 803072 | 465 | 196928 | 34 |
| 27 | 729621 | 331 | 926270 | 134 | 803351 | 465 | 196649 | 33 |
| 28 | 729820 | 331 | 926190 | 134 | 803630 | 465 | 196370 | 32 |
| 29 | 730018 | 330 | 926110 | 134 | 803908 | 465 | 196092 | 31 |
| 30 | 730216 | 330 | 926029 | 134 | 804187 | 465 | 195813 | 30 |
| 31 | 9·730415 | 330 | 9·925949 | 134 | 9·804466 | 464 | 10·195534 | 29 |
| 32 | 730613 | 330 | 925868 | 134 | 804745 | 464 | 195255 | 28 |
| 33 | 730811 | 330 | 925788 | 134 | 805023 | 464 | 194977 | 27 |
| 34 | 731009 | 329 | 925707 | 134 | 805302 | 464 | 194698 | 26 |
| 35 | 731206 | 329 | 925626 | 134 | 805580 | 464 | 194420 | 25 |
| 36 | 731404 | 329 | 925545 | 135 | 805859 | 464 | 194141 | 24 |
| 37 | 731602 | 329 | 925465 | 135 | 806137 | 464 | 193863 | 23 |
| 38 | 731799 | 329 | 925384 | 135 | 806415 | 463 | 193585 | 22 |
| 39 | 731996 | 328 | 925303 | 135 | 806693 | 463 | 193307 | 21 |
| 40 | 732193 | 328 | 925222 | 135 | 806971 | 463 | 193029 | 20 |
| 41 | 9·732390 | 328 | 9·925141 | 135 | 9·807249 | 463 | 10·192751 | 19 |
| 42 | 732587 | 328 | 925060 | 135 | 807527 | 463 | 192473 | 18 |
| 43 | 732784 | 328 | 924979 | 135 | 807805 | 463 | 192195 | 17 |
| 44 | 732980 | 327 | 924897 | 135 | 808083 | 463 | 191917 | 16 |
| 45 | 733177 | 327 | 924816 | 135 | 808361 | 463 | 191639 | 15 |
| 46 | 733373 | 327 | 924735 | 136 | 808638 | 462 | 191362 | 14 |
| 47 | 733569 | 327 | 924654 | 136 | 808916 | 462 | 191084 | 13 |
| 48 | 733765 | 327 | 924572 | 136 | 809193 | 462 | 190807 | 12 |
| 49 | 733961 | 326 | 924491 | 136 | 809471 | 462 | 190529 | 11 |
| 50 | 734157 | 326 | 924409 | 136 | 809748 | 462 | 190252 | 10 |
| 51 | 9·734353 | 326 | 9·924328 | 136 | 9·810025 | 462 | 10·189975 | 9 |
| 52 | 734549 | 326 | 924246 | 136 | 810302 | 462 | 189698 | 8 |
| 53 | 734744 | 325 | 924164 | 136 | 810580 | 462 | 189420 | 7 |
| 54 | 734939 | 325 | 924083 | 136 | 810857 | 462 | 189143 | 6 |
| 55 | 735135 | 325 | 924001 | 136 | 811134 | 461 | 188866 | 5 |
| 56 | 735330 | 325 | 923919 | 136 | 811410 | 461 | 188590 | 4 |
| 57 | 735525 | 325 | 923837 | 136 | 811687 | 461 | 188313 | 3 |
| 58 | 735719 | 324 | 923755 | 137 | 811964 | 461 | 188036 | 2 |
| 59 | 735914 | 324 | 923673 | 137 | 812241 | 461 | 187759 | 1 |
| 60 | 736109 | 324 | 923591 | 137 | 812517 | 461 | 187483 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·736109 | 324 | 9·923591 | 137 | 9·812517 | 461 | 10·187482 | 60 |
| 1 | 736303 | 324 | 923509 | 137 | 812794 | 461 | 187206 | 59 |
| 2 | 736498 | 324 | 923427 | 137 | 813070 | 461 | 186930 | 58 |
| 3 | 736692 | 323 | 923345 | 137 | 813347 | 460 | 186653 | 57 |
| 4 | 736886 | 323 | 923263 | 137 | 813623 | 460 | 186377 | 56 |
| 5 | 737080 | 323 | 923181 | 137 | 813899 | 460 | 186101 | 55 |
| 6 | 737274 | 323 | 923098 | 137 | 814175 | 460 | 185825 | 54 |
| 7 | 737467 | 323 | 923016 | 137 | 814452 | 460 | 185548 | 53 |
| 8 | 737661 | 322 | 922933 | 137 | 814728 | 460 | 185272 | 52 |
| 9 | 737855 | 322 | 922851 | 137 | 815004 | 460 | 184996 | 51 |
| 10 | 738048 | 322 | 922768 | 138 | 815279 | 460 | 184721 | 50 |
| 11 | 9·738241 | 322 | 9·922686 | 138 | 9·815555 | 459 | 10·184445 | 49 |
| 12 | 738434 | 322 | 922603 | 138 | 815831 | 459 | 184169 | 48 |
| 13 | 738627 | 321 | 922520 | 138 | 816107 | 459 | 183893 | 47 |
| 14 | 738820 | 321 | 922438 | 138 | 816382 | 459 | 183618 | 46 |
| 15 | 739013 | 321 | 922355 | 138 | 816658 | 459 | 183342 | 45 |
| 16 | 739206 | 321 | 922272 | 138 | 816933 | 459 | 183067 | 44 |
| 17 | 739398 | 321 | 922189 | 138 | 817209 | 459 | 182791 | 43 |
| 18 | 739590 | 320 | 922106 | 138 | 817484 | 459 | 182516 | 42 |
| 19 | 739783 | 320 | 922023 | 138 | 817759 | 459 | 182241 | 41 |
| 20 | 739975 | 320 | 921940 | 138 | 818035 | 458 | 181965 | 40 |
| 21 | 9·740167 | 320 | 9·921857 | 139 | 9·818310 | 458 | 10·181690 | 39 |
| 22 | 740359 | 320 | 921774 | 139 | 818585 | 458 | 181415 | 38 |
| 23 | 740550 | 319 | 921691 | 139 | 818860 | 458 | 181140 | 37 |
| 24 | 740742 | 319 | 921607 | 139 | 819135 | 458 | 180865 | 36 |
| 25 | 740934 | 319 | 921524 | 139 | 819410 | 458 | 180590 | 35 |
| 26 | 741125 | 319 | 921441 | 139 | 819684 | 458 | 180316 | 34 |
| 27 | 741316 | 319 | 921357 | 139 | 819959 | 458 | 180041 | 33 |
| 28 | 741508 | 318 | 921274 | 139 | 820234 | 458 | 179766 | 32 |
| 29 | 741699 | 318 | 921190 | 139 | 820508 | 457 | 179492 | 31 |
| 30 | 741889 | 318 | 921107 | 139 | 820783 | 457 | 179217 | 30 |
| 31 | 9·742080 | 318 | 9·921023 | 139 | 9·821057 | 457 | 10·178943 | 29 |
| 32 | 742271 | 318 | 920939 | 140 | 821332 | 457 | 178668 | 28 |
| 33 | 742462 | 317 | 920856 | 140 | 821606 | 457 | 178394 | 27 |
| 34 | 742652 | 317 | 920772 | 140 | 821880 | 457 | 178120 | 26 |
| 35 | 742842 | 317 | 920688 | 140 | 822154 | 457 | 177846 | 25 |
| 36 | 743033 | 317 | 920604 | 140 | 822429 | 457 | 177571 | 24 |
| 37 | 743223 | 317 | 920520 | 140 | 822703 | 457 | 177297 | 23 |
| 38 | 743413 | 316 | 920436 | 140 | 822977 | 456 | 177023 | 22 |
| 39 | 743602 | 316 | 920352 | 140 | 823250 | 456 | 176750 | 21 |
| 40 | 743792 | 316 | 920268 | 140 | 823524 | 456 | 176476 | 20 |
| 41 | 9·743982 | 316 | 9·920184 | 140 | 9·823798 | 456 | 10·176202 | 19 |
| 42 | 744171 | 316 | 920099 | 140 | 824072 | 456 | 175928 | 18 |
| 43 | 744361 | 315 | 920015 | 140 | 824345 | 456 | 175655 | 17 |
| 44 | 744550 | 315 | 919931 | 141 | 824619 | 456 | 175381 | 16 |
| 45 | 744739 | 315 | 919846 | 141 | 824893 | 456 | 175107 | 15 |
| 46 | 744928 | 315 | 919762 | 141 | 825166 | 456 | 174834 | 14 |
| 47 | 745117 | 315 | 919677 | 141 | 825439 | 455 | 174561 | 13 |
| 48 | 745306 | 314 | 919593 | 141 | 825713 | 455 | 174287 | 12 |
| 49 | 745494 | 314 | 919508 | 141 | 825986 | 455 | 174014 | 11 |
| 50 | 745683 | 314 | 919424 | 141 | 826259 | 455 | 173741 | 10 |
| 51 | 9·745871 | 314 | 9·919339 | 141 | 9·826532 | 455 | 10·173468 | 9 |
| 52 | 746059 | 314 | 919254 | 141 | 826805 | 455 | 173195 | 8 |
| 53 | 746248 | 313 | 919169 | 141 | 827078 | 455 | 172922 | 7 |
| 54 | 746436 | 313 | 919085 | 141 | 827351 | 455 | 172649 | 6 |
| 55 | 746624 | 313 | 919000 | 141 | 827624 | 455 | 172376 | 5 |
| 56 | 746812 | 313 | 918915 | 142 | 827897 | 454 | 172103 | 4 |
| 57 | 746999 | 313 | 918830 | 142 | 828170 | 454 | 171830 | 3 |
| 58 | 747187 | 312 | 918745 | 142 | 828442 | 454 | 171558 | 2 |
| 59 | 747374 | 312 | 918659 | 142 | 828715 | 454 | 171285 | 1 |
| 60 | 747562 | 312 | 918574 | 142 | 828987 | 454 | 171013 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·747562 | 312 | 9·918574 | 142 | 9·828987 | 454 | 10·171013 | 60 |
| 1 | 747749 | 312 | 918489 | 142 | 829260 | 454 | 170740 | 59 |
| 2 | 747936 | 312 | 918404 | 142 | 829532 | 454 | 170468 | 58 |
| 3 | 748123 | 311 | 918318 | 142 | 829805 | 454 | 170195 | 57 |
| 4 | 748310 | 311 | 918233 | 142 | 830077 | 454 | 169923 | 56 |
| 5 | 748497 | 311 | 918147 | 142 | 830349 | 453 | 169651 | 55 |
| 6 | 748683 | 311 | 918062 | 142 | 830621 | 453 | 169379 | 54 |
| 7 | 748870 | 311 | 917976 | 143 | 830893 | 453 | 169107 | 53 |
| 8 | 749056 | 310 | 917891 | 143 | 831165 | 453 | 168835 | 52 |
| 9 | 749243 | 310 | 917805 | 143 | 831437 | 453 | 168563 | 51 |
| 10 | 749429 | 310 | 917719 | 143 | 831709 | 453 | 168291 | 50 |
| 11 | 9·749615 | 310 | 9·917634 | 143 | 9·831981 | 453 | 10·168019 | 49 |
| 12 | 749801 | 310 | 917548 | 143 | 832253 | 453 | 167747 | 48 |
| 13 | 749987 | 309 | 917462 | 143 | 832525 | 453 | 167475 | 47 |
| 14 | 750172 | 309 | 917376 | 143 | 832796 | 453 | 167204 | 46 |
| 15 | 750358 | 309 | 917290 | 143 | 833068 | 452 | 166932 | 45 |
| 16 | 750543 | 309 | 917204 | 143 | 833339 | 452 | 166661 | 44 |
| 17 | 750729 | 309 | 917118 | 144 | 833611 | 452 | 166389 | 43 |
| 18 | 750914 | 308 | 917032 | 144 | 833882 | 452 | 166118 | 42 |
| 19 | 751099 | 308 | 916946 | 144 | 834154 | 452 | 165846 | 41 |
| 20 | 751284 | 308 | 916859 | 144 | 834425 | 452 | 165575 | 40 |
| 21 | 9·751469 | 308 | 9·916773 | 144 | 9·834696 | 452 | 10·165304 | 39 |
| 22 | 751654 | 308 | 916687 | 144 | 834967 | 452 | 165033 | 38 |
| 23 | 751839 | 308 | 916600 | 144 | 835238 | 452 | 164762 | 37 |
| 24 | 752023 | 307 | 916514 | 144 | 835509 | 452 | 164491 | 36 |
| 25 | 752208 | 307 | 916427 | 144 | 835780 | 451 | 164220 | 35 |
| 26 | 752392 | 307 | 916341 | 144 | 836051 | 451 | 163949 | 34 |
| 27 | 752576 | 307 | 916254 | 144 | 836322 | 451 | 163678 | 33 |
| 28 | 752760 | 307 | 916167 | 145 | 836593 | 451 | 163407 | 32 |
| 29 | 752944 | 306 | 916081 | 145 | 836864 | 451 | 163136 | 31 |
| 30 | 753128 | 306 | 915994 | 145 | 837134 | 451 | 162866 | 30 |
| 31 | 9·753312 | 306 | 9·915907 | 145 | 9·837405 | 451 | 10·162595 | 29 |
| 32 | 753495 | 306 | 915820 | 145 | 837675 | 451 | 162325 | 28 |
| 33 | 753679 | 306 | 915733 | 145 | 837946 | 451 | 162054 | 27 |
| 34 | 753862 | 305 | 915646 | 145 | 838216 | 451 | 161784 | 26 |
| 35 | 754046 | 305 | 915559 | 145 | 838487 | 450 | 161513 | 25 |
| 36 | 754229 | 305 | 915472 | 145 | 838757 | 450 | 161243 | 24 |
| 37 | 754412 | 305 | 915385 | 145 | 839027 | 450 | 160973 | 23 |
| 38 | 754595 | 305 | 915297 | 145 | 839297 | 450 | 160703 | 22 |
| 39 | 754778 | 304 | 915210 | 145 | 839568 | 450 | 160432 | 21 |
| 40 | 754960 | 304 | 915123 | 146 | 839838 | 450 | 160162 | 20 |
| 41 | 9·755143 | 304 | 9·915035 | 146 | 9·840108 | 450 | 10·159892 | 19 |
| 42 | 755326 | 304 | 914948 | 146 | 840378 | 450 | 159622 | 18 |
| 43 | 755508 | 304 | 914860 | 146 | 840647 | 450 | 159353 | 17 |
| 44 | 755690 | 304 | 914773 | 146 | 840917 | 449 | 159083 | 16 |
| 45 | 755872 | 303 | 914685 | 146 | 841187 | 449 | 158813 | 15 |
| 46 | 756054 | 303 | 914598 | 146 | 841457 | 449 | 158543 | 14 |
| 47 | 756236 | 303 | 914510 | 146 | 841726 | 449 | 158274 | 13 |
| 48 | 756418 | 303 | 914422 | 146 | 841996 | 449 | 158004 | 12 |
| 49 | 756600 | 303 | 914334 | 146 | 842266 | 449 | 157734 | 11 |
| 50 | 756782 | 302 | 914246 | 147 | 842535 | 449 | 157465 | 10 |
| 51 | 9·756963 | 302 | 9·914158 | 147 | 9·842805 | 449 | 10·157195 | 9 |
| 52 | 757144 | 302 | 914070 | 147 | 843074 | 449 | 156926 | 8 |
| 53 | 757326 | 302 | 913982 | 147 | 843343 | 449 | 156657 | 7 |
| 54 | 757507 | 302 | 913894 | 147 | 843612 | 449 | 156388 | 6 |
| 55 | 757688 | 301 | 913806 | 147 | 843882 | 448 | 156118 | 5 |
| 56 | 757869 | 301 | 913718 | 147 | 844151 | 448 | 155849 | 4 |
| 57 | 758050 | 301 | 913630 | 147 | 844420 | 448 | 155580 | 3 |
| 58 | 758230 | 301 | 913541 | 147 | 844689 | 448 | 155311 | 2 |
| 59 | 758411 | 301 | 913453 | 147 | 844958 | 448 | 155042 | 1 |
| 60 | 758591 | 301 | 913365 | 147 | 845227 | 448 | 154773 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·758591 | 301 | 9·913365 | 147 | 9.845227 | 448 | 10·154773 | 60 |
| 1 | 758772 | 300 | 913276 | 147 | 845496 | 448 | 154504 | 59 |
| 2 | 758952 | 300 | 913187 | 148 | 845764 | 448 | 154236 | 58 |
| 3 | 759132 | 300 | 913099 | 148 | 846033 | 448 | 153967 | 57 |
| 4 | 759312 | 300 | 913010 | 148 | 846302 | 448 | 153698 | 56 |
| 5 | 759492 | 300 | 912922 | 148 | 846570 | 447 | 153430 | 55 |
| 6 | 759672 | 299 | 912833 | 148 | 846839 | 447 | 153161 | 54 |
| 7 | 759852 | 299 | 912744 | 148 | 847107 | 447 | 152893 | 53 |
| 8 | 760031 | 299 | 912655 | 148 | 847376 | 447 | 152624 | 52 |
| 9 | 760211 | 299 | 912566 | 148 | 847644 | 447 | 152356 | 51 |
| 10 | 760390 | 299 | 912477 | 148 | 847913 | 447 | 152087 | 50 |
| 11 | 9·760569 | 298 | 9·912388 | 148 | 9.848181 | 447 | 10·151819 | 49 |
| 12 | 760748 | 298 | 912299 | 149 | 848449 | 447 | 151551 | 48 |
| 13 | 760927 | 298 | 912210 | 149 | 848717 | 447 | 151283 | 47 |
| 14 | 761106 | 298 | 912121 | 149 | 848986 | 447 | 151014 | 46 |
| 15 | 761285 | 298 | 912031 | 149 | 849254 | 447 | 150746 | 45 |
| 16 | 761464 | 298 | 911942 | 149 | 849522 | 447 | 150478 | 44 |
| 17 | 761642 | 297 | 911853 | 149 | 849790 | 446 | 150210 | 43 |
| 18 | 761821 | 297 | 911763 | 149 | 850058 | 446 | 149942 | 42 |
| 19 | 761999 | 297 | 911674 | 149 | 850325 | 446 | 149675 | 41 |
| 20 | 762177 | 297 | 911584 | 149 | 850593 | 446 | 149407 | 40 |
| 21 | 9·762356 | 297 | 9·911495 | 149 | 9·850861 | 446 | 10·149139 | 39 |
| 22 | 762534 | 296 | 911405 | 149 | 851129 | 446 | 148871 | 38 |
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| 24 | 762889 | 296 | 911226 | 150 | 851664 | 446 | 148336 | 36 |
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| 26 | 763245 | 296 | 911046 | 150 | 852199 | 446 | 147801 | 34 |
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| 31 | 9·764131 | 295 | 9·910596 | 150 | 9·853535 | 445 | 10·146465 | 29 |
| 32 | 764308 | 295 | 910506 | 150 | 853802 | 445 | 146198 | 28 |
| 33 | 764485 | 294 | 910415 | 150 | 854069 | 445 | 145931 | 27 |
| 34 | 764662 | 294 | 910325 | 151 | 854336 | 445 | 145664 | 26 |
| 35 | 764838 | 294 | 910235 | 151 | 854603 | 445 | 145397 | 25 |
| 36 | 765015 | 294 | 910144 | 151 | 854870 | 445 | 145130 | 24 |
| 37 | 765191 | 294 | 910054 | 151 | 855137 | 445 | 144863 | 23 |
| 38 | 765367 | 294 | 909963 | 151 | 855404 | 445 | 144596 | 22 |
| 39 | 765544 | 293 | 909873 | 151 | 855671 | 444 | 144329 | 21 |
| 40 | 765720 | 293 | 909782 | 151 | 855938 | 444 | 144062 | 20 |
| 41 | 9·765896 | 293 | 9·909691 | 151 | 9·856204 | 444 | 10·143796 | 19 |
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| 43 | 766247 | 293 | 909510 | 151 | 856737 | 444 | 143263 | 17 |
| 44 | 766423 | 293 | 909419 | 151 | 857004 | 444 | 142996 | 16 |
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| 46 | 766774 | 292 | 909237 | 152 | 857537 | 444 | 142463 | 14 |
| 47 | 766949 | 292 | 909146 | 152 | 857803 | 444 | 142197 | 13 |
| 48 | 767124 | 292 | 909055 | 152 | 858069 | 444 | 141931 | 12 |
| 49 | 767300 | 292 | 908964 | 152 | 858336 | 444 | 141664 | 11 |
| 50 | 767475 | 291 | 908873 | 152 | 858602 | 443 | 141398 | 10 |
| 51 | 9·767649 | 291 | 9·908781 | 152 | 9·858868 | 443 | 10·141122 | 9 |
| 52 | 767824 | 291 | 908690 | 152 | 859134 | 443 | 140866 | 8 |
| 53 | 767999 | 291 | 908599 | 152 | 859400 | 443 | 140600 | 7 |
| 54 | 768173 | 291 | 908507 | 152 | 859666 | 443 | 140334 | 6 |
| 55 | 768348 | 290 | 908416 | 153 | 859932 | 443 | 140068 | 5 |
| 56 | 768522 | 290 | 908324 | 153 | 860198 | 443 | 139802 | 4 |
| 57 | 768697 | 290 | 908233 | 153 | 860464 | 443 | 139536 | 3 |
| 58 | 768871 | 290 | 908141 | 153 | 860730 | 443 | 139270 | 2 |
| 59 | 769045 | 290 | 908049 | 153 | 860995 | 443 | 139005 | 1 |
| 60 | 769219 | 290 | 907958 | 153 | 861261 | 443 | 138739 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

54 Degrees.

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·769219 | 290 | 9·907958 | 153 | 9·861261 | 443 | 10·138739 | 60 |
| 1 | 769393 | 289 | 907806 | 153 | 861527 | 443 | 138473 | 59 |
| 2 | 769566 | 289 | 907774 | 153 | 861792 | 442 | 138208 | 58 |
| 3 | 769740 | 289 | 907622 | 153 | 862058 | 442 | 137942 | 57 |
| 4 | 769913 | 289 | 907590 | 153 | 862323 | 442 | 137677 | 56 |
| 5 | 770087 | 289 | 907498 | 153 | 862589 | 442 | 137411 | 55 |
| 6 | 770260 | 288 | 907406 | 153 | 862854 | 442 | 137146 | 54 |
| 7 | 770433 | 288 | 907314 | 154 | 863119 | 442 | 136881 | 53 |
| 8 | 770606 | 288 | 907222 | 154 | 863385 | 442 | 136615 | 52 |
| 9 | 770779 | 288 | 907129 | 154 | 863650 | 442 | 136350 | 51 |
| 10 | 770952 | 288 | 907037 | 154 | 863915 | 442 | 136085 | 50 |
| 11 | 9·771125 | 288 | 9·906945 | 154 | 9·864180 | 442 | 10·135820 | 49 |
| 12 | 771298 | 287 | 906852 | 154 | 864445 | 442 | 135555 | 48 |
| 13 | 771470 | 287 | 906760 | 154 | 864710 | 442 | 135290 | 47 |
| 14 | 771643 | 287 | 906667 | 154 | 864975 | 441 | 135025 | 46 |
| 15 | 771815 | 287 | 906575 | 154 | 865240 | 441 | 134760 | 45 |
| 16 | 771987 | 287 | 906482 | 154 | 865505 | 441 | 134495 | 44 |
| 17 | 772159 | 287 | 906389 | 155 | 865770 | 441 | 134230 | 43 |
| 18 | 772331 | 286 | 906296 | 155 | 866035 | 441 | 133965 | 42 |
| 19 | 772503 | 286 | 906204 | 155 | 866300 | 441 | 133700 | 41 |
| 20 | 772675 | 286 | 906111 | 155 | 866564 | 441 | 133436 | 40 |
| 21 | 9·772847 | 286 | 9·906018 | 155 | 9·866829 | 441 | 10·133171 | 39 |
| 22 | 773018 | 286 | 905925 | 155 | 867094 | 441 | 132906 | 38 |
| 23 | 773190 | 286 | 905832 | 155 | 867358 | 441 | 132642 | 37 |
| 24 | 773361 | 285 | 905739 | 155 | 867623 | 441 | 132377 | 36 |
| 25 | 773533 | 285 | 905645 | 155 | 867887 | 441 | 132113 | 35 |
| 26 | 773704 | 285 | 905552 | 155 | 868152 | 440 | 131848 | 34 |
| 27 | 773875 | 285 | 905459 | 155 | 868416 | 440 | 131584 | 33 |
| 28 | 774046 | 285 | 905366 | 156 | 868680 | 440 | 131320 | 32 |
| 29 | 774217 | 285 | 905272 | 156 | 868945 | 440 | 131055 | 31 |
| 30 | 774388 | 284 | 905179 | 156 | 869209 | 440 | 130791 | 30 |
| 31 | 9·774558 | 284 | 9·905085 | 156 | 9·869473 | 440 | 10·130527 | 29 |
| 32 | 774729 | 284 | 904992 | 156 | 869737 | 440 | 130263 | 28 |
| 33 | 774899 | 284 | 904898 | 156 | 870001 | 440 | 129999 | 27 |
| 34 | 775070 | 284 | 904804 | 156 | 870265 | 440 | 129735 | 26 |
| 35 | 775240 | 284 | 904711 | 156 | 870529 | 440 | 129471 | 25 |
| 36 | 775410 | 283 | 904617 | 156 | 870793 | 440 | 129207 | 24 |
| 37 | 775580 | 283 | 904523 | 156 | 871057 | 440 | 128943 | 23 |
| 38 | 775750 | 283 | 904429 | 157 | 871321 | 440 | 128679 | 22 |
| 39 | 775920 | 283 | 904335 | 157 | 871585 | 440 | 128415 | 21 |
| 40 | 776090 | 283 | 904241 | 157 | 871849 | 439 | 128151 | 20 |
| 41 | 9·776259 | 283 | 9·904147 | 157 | 9·872112 | 439 | 10·127888 | 19 |
| 42 | 776429 | 282 | 904053 | 157 | 872376 | 439 | 127624 | 18 |
| 43 | 776598 | 282 | 903959 | 157 | 872640 | 439 | 127360 | 17 |
| 44 | 776768 | 282 | 903864 | 157 | 872903 | 439 | 127097 | 16 |
| 45 | 776937 | 282 | 903770 | 157 | 873167 | 439 | 126833 | 15 |
| 46 | 777106 | 282 | 903676 | 157 | 873430 | 439 | 126570 | 14 |
| 47 | 777275 | 281 | 903581 | 157 | 873694 | 439 | 126306 | 13 |
| 48 | 777444 | 281 | 903487 | 157 | 873957 | 439 | 126043 | 12 |
| 49 | 777613 | 281 | 903392 | 158 | 874220 | 439 | 125780 | 11 |
| 50 | 777781 | 281 | 903298 | 158 | 874484 | 439 | 125516 | 10 |
| 51 | 9·777950 | 281 | 9·903203 | 158 | 9·874747 | 439 | 10·125253 | 9 |
| 52 | 778119 | 281 | 903108 | 158 | 875010 | 439 | 124990 | 8 |
| 53 | 778287 | 280 | 903014 | 158 | 875273 | 438 | 124727 | 7 |
| 54 | 778455 | 280 | 902919 | 158 | 875536 | 438 | 124464 | 6 |
| 55 | 778624 | 280 | 902824 | 158 | 875800 | 438 | 124200 | 5 |
| 56 | 778792 | 280 | 902729 | 158 | 876063 | 438 | 123937 | 4 |
| 57 | 778960 | 280 | 902634 | 158 | 876326 | 438 | 123674 | 3 |
| 58 | 779128 | 280 | 902539 | 159 | 876589 | 438 | 123411 | 2 |
| 59 | 779295 | 279 | 902444 | 159 | 876851 | 438 | 123149 | 1 |
| 60 | 779463 | 279 | 902349 | 159 | 877114 | 438 | 122886 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·779463 | 279 | 9·902349 | 159 | 9·877114 | 438 | 10·122886 | 60 |
| 1 | 779631 | 279 | 902253 | 159 | 877377 | 438 | 122623 | 59 |
| 2 | 779798 | 279 | 902158 | 159 | 877640 | 438 | 122360 | 58 |
| 3 | 779966 | 279 | 902063 | 159 | 877903 | 438 | 122097 | 57 |
| 4 | 780133 | 279 | 901967 | 159 | 878165 | 438 | 121835 | 56 |
| 5 | 780300 | 278 | 901872 | 159 | 878428 | 438 | 121572 | 55 |
| 6 | 780467 | 278 | 901776 | 159 | 878691 | 438 | 121309 | 54 |
| 7 | 780634 | 278 | 901681 | 159 | 878953 | 437 | 121047 | 53 |
| 8 | 780801 | 278 | 901585 | 159 | 879216 | 437 | 120784 | 52 |
| 9 | 780968 | 278 | 901490 | 159 | 879478 | 437 | 120522 | 51 |
| 10 | 781134 | 278 | 901394 | 160 | 879741 | 437 | 120259 | 50 |
| 11 | 9·781301 | 277 | 9·901298 | 160 | 9·880003 | 437 | 10·119997 | 49 |
| 12 | 781468 | 277 | 901202 | 160 | 880265 | 437 | 119735 | 48 |
| 13 | 781634 | 277 | 901106 | 160 | 880528 | 437 | 119472 | 47 |
| 14 | 781800 | 277 | 901010 | 160 | 880790 | 437 | 119210 | 46 |
| 15 | 781966 | 277 | 900914 | 160 | 881052 | 437 | 118948 | 45 |
| 16 | 782132 | 277 | 900818 | 160 | 881314 | 437 | 118686 | 44 |
| 17 | 782298 | 276 | 900722 | 160 | 881576 | 437 | 118424 | 43 |
| 18 | 782464 | 276 | 900626 | 160 | 881839 | 437 | 118161 | 42 |
| 19 | 782630 | 276 | 900529 | 160 | 882101 | 437 | 117899 | 41 |
| 20 | 782796 | 276 | 900433 | 161 | 882363 | 436 | 117637 | 40 |
| 21 | 9·782961 | 276 | 9·900337 | 161 | 9·882625 | 436 | 10·117375 | 39 |
| 22 | 783127 | 276 | 900240 | 161 | 882887 | 436 | 117113 | 38 |
| 23 | 783292 | 275 | 900144 | 161 | 883148 | 436 | 116852 | 37 |
| 24 | 783458 | 275 | 900047 | 161 | 883410 | 436 | 116590 | 36 |
| 25 | 783623 | 275 | 899951 | 161 | 883672 | 436 | 116328 | 35 |
| 26 | 783788 | 275 | 899854 | 161 | 883934 | 436 | 116066 | 34 |
| 27 | 783953 | 275 | 899757 | 161 | 884196 | 436 | 115804 | 33 |
| 28 | 784118 | 275 | 899660 | 161 | 884457 | 436 | 115543 | 32 |
| 29 | 784282 | 274 | 899564 | 161 | 884719 | 436 | 115281 | 31 |
| 30 | 784447 | 274 | 899467 | 162 | 884980 | 436 | 115020 | 30 |
| 31 | 9·784612 | 274 | 9·899370 | 162 | 9·885242 | 436 | 10·114758 | 29 |
| 32 | 784776 | 274 | 899273 | 162 | 885503 | 436 | 114497 | 28 |
| 33 | 784941 | 274 | 899176 | 162 | 885765 | 436 | 114235 | 27 |
| 34 | 785105 | 274 | 899078 | 162 | 886026 | 436 | 113974 | 26 |
| 35 | 785269 | 273 | 898981 | 162 | 886288 | 436 | 113712 | 25 |
| 36 | 785433 | 273 | 898884 | 162 | 886549 | 435 | 113451 | 24 |
| 37 | 785597 | 273 | 898787 | 162 | 886810 | 435 | 113190 | 23 |
| 38 | 785761 | 273 | 898689 | 162 | 887072 | 435 | 112928 | 22 |
| 39 | 785925 | 273 | 898592 | 162 | 887333 | 435 | 112667 | 21 |
| 40 | 786089 | 273 | 898494 | 163 | 887594 | 435 | 112406 | 20 |
| 41 | 9·786252 | 272 | 9·898397 | 163 | 9·887855 | 435 | 10·112145 | 19 |
| 42 | 786416 | 272 | 898299 | 163 | 888116 | 435 | 111884 | 18 |
| 43 | 786579 | 272 | 898202 | 163 | 888377 | 435 | 111623 | 17 |
| 44 | 786742 | 272 | 898104 | 163 | 888639 | 435 | 111361 | 16 |
| 45 | 786906 | 272 | 898006 | 163 | 888900 | 435 | 111100 | 15 |
| 46 | 787069 | 272 | 897908 | 163 | 889160 | 435 | 110840 | 14 |
| 47 | 787232 | 271 | 897810 | 163 | 889421 | 435 | 110579 | 13 |
| 48 | 787395 | 271 | 897712 | 163 | 889682 | 435 | 110318 | 12 |
| 49 | 787557 | 271 | 897614 | 163 | 889943 | 435 | 110057 | 11 |
| 50 | 787720 | 271 | 897516 | 163 | 890204 | 434 | 119796 | 10 |
| 51 | 9·787883 | 271 | 9·897418 | 164 | 9·890465 | 434 | 10·109535 | 9 |
| 52 | 788045 | 271 | 897320 | 164 | 890725 | 434 | 109275 | 8 |
| 53 | 788208 | 271 | 897222 | 164 | 890986 | 434 | 109014 | 7 |
| 54 | 788370 | 270 | 897123 | 164 | 891247 | 434 | 108753 | 6 |
| 55 | 788532 | 270 | 897025 | 164 | 891507 | 434 | 108493 | 5 |
| 56 | 788694 | 270 | 896926 | 164 | 891768 | 434 | 108232 | 4 |
| 57 | 788856 | 270 | 896828 | 164 | 892028 | 434 | 107972 | 3 |
| 58 | 789018 | 270 | 896729 | 164 | 892289 | 434 | 107711 | 2 |
| 59 | 789180 | 270 | 896631 | 164 | 892549 | 434 | 107451 | 1 |
| 60 | 789342 | 269 | 896532 | 164 | 892810 | 434 | 107190 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

52 Degrees.

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·789342 | 269 | 9·896532 | 164 | 9·892810 | 434 | 10·107190 | 60 |
| 1 | 789504 | 269 | 896433 | 165 | 893070 | 434 | 106930 | 59 |
| 2 | 789665 | 269 | 896335 | 165 | 893331 | 434 | 106669 | 58 |
| 3 | 789827 | 269 | 896236 | 165 | 893591 | 434 | 106409 | 57 |
| 4 | 789988 | 269 | 896137 | 165 | 893851 | 434 | 106149 | 56 |
| 5 | 790149 | 269 | 896038 | 165 | 894111 | 434 | 105889 | 55 |
| 6 | 790310 | 268 | 895939 | 165 | 894371 | 434 | 105629 | 54 |
| 7 | 790471 | 268 | 895840 | 165 | 894632 | 433 | 105368 | 53 |
| 8 | 790632 | 268 | 895741 | 165 | 894892 | 433 | 105108 | 52 |
| 9 | 790793 | 268 | 895641 | 165 | 895152 | 433 | 104848 | 51 |
| 10 | 790954 | 268 | 895542 | 165 | 895412 | 433 | 104588 | 50 |
| 11 | 9·791115 | 268 | 9·895443 | 166 | 9·895672 | 433 | 10·104328 | 49 |
| 12 | 791275 | 267 | 895343 | 166 | 895932 | 433 | 104068 | 48 |
| 13 | 791436 | 267 | 895244 | 166 | 896192 | 433 | 103808 | 47 |
| 14 | 791596 | 267 | 895145 | 166 | 896452 | 433 | 103548 | 46 |
| 15 | 791757 | 267 | 895045 | 166 | 896712 | 433 | 103288 | 45 |
| 16 | 791917 | 267 | 894945 | 166 | 896971 | 433 | 103029 | 44 |
| 17 | 792077 | 267 | 894846 | 166 | 897231 | 433 | 102769 | 43 |
| 18 | 792237 | 266 | 894746 | 166 | 897491 | 433 | 102509 | 42 |
| 19 | 792397 | 266 | 894646 | 166 | 897751 | 433 | 102249 | 41 |
| 20 | 792557 | 266 | 894546 | 166 | 898010 | 433 | 101990 | 40 |
| 21 | 9·792716 | 266 | 9·894446 | 167 | 9·898270 | 433 | 10·101730 | 39 |
| 22 | 792876 | 266 | 894346 | 167 | 898530 | 433 | 101470 | 38 |
| 23 | 793035 | 266 | 894246 | 167 | 898789 | 433 | 101211 | 37 |
| 24 | 793195 | 265 | 894146 | 167 | 899049 | 432 | 100951 | 36 |
| 25 | 793354 | 265 | 894046 | 167 | 899308 | 432 | 100692 | 35 |
| 26 | 793514 | 265 | 893946 | 167 | 899568 | 432 | 100432 | 34 |
| 27 | 793673 | 265 | 893846 | 167 | 899827 | 432 | 100173 | 33 |
| 28 | 793832 | 265 | 893745 | 167 | 900086 | 432 | 099914 | 32 |
| 29 | 793991 | 265 | 893645 | 167 | 900346 | 432 | 099654 | 31 |
| 30 | 794150 | 264 | 893544 | 167 | 900605 | 432 | 099395 | 30 |
| 31 | 9·794308 | 264 | 9·893444 | 168 | 9·900864 | 432 | 10·099136 | 29 |
| 32 | 794467 | 264 | 893343 | 168 | 901124 | 432 | 098876 | 28 |
| 33 | 794626 | 264 | 893243 | 168 | 901383 | 432 | 098617 | 27 |
| 34 | 794784 | 264 | 893142 | 168 | 901642 | 432 | 098358 | 26 |
| 35 | 794942 | 264 | 893041 | 168 | 901901 | 432 | 098099 | 25 |
| 36 | 795101 | 264 | 892940 | 168 | 902160 | 432 | 097840 | 24 |
| 37 | 795259 | 264 | 892839 | 168 | 902419 | 432 | 097581 | 23 |
| 38 | 795417 | 263 | 892739 | 168 | 902679 | 432 | 097321 | 22 |
| 39 | 795575 | 263 | 892638 | 168 | 902938 | 432 | 097062 | 21 |
| 40 | 795733 | 263 | 892536 | 168 | 903197 | 431 | 096803 | 20 |
| 41 | 9·795891 | 263 | 9·892435 | 169 | 9·903455 | 431 | 10·096545 | 19 |
| 42 | 796049 | 263 | 892334 | 169 | 903714 | 431 | 096286 | 18 |
| 43 | 796206 | 263 | 892233 | 169 | 903973 | 431 | 096027 | 17 |
| 44 | 796364 | 262 | 892132 | 169 | 904232 | 431 | 095768 | 16 |
| 45 | 796521 | 262 | 892030 | 169 | 904491 | 431 | 095509 | 15 |
| 46 | 796679 | 262 | 891929 | 169 | 904750 | 431 | 095250 | 14 |
| 47 | 796836 | 262 | 891827 | 169 | 905008 | 431 | 094992 | 13 |
| 48 | 796993 | 262 | 891726 | 169 | 905267 | 431 | 094733 | 12 |
| 49 | 797150 | 261 | 891624 | 169 | 905526 | 431 | 094474 | 11 |
| 50 | 797307 | 261 | 891523 | 170 | 905784 | 431 | 094216 | 10 |
| 51 | 9·797464 | 261 | 9·891421 | 170 | 9·906043 | 431 | 10·093957 | 9 |
| 52 | 797621 | 261 | 891319 | 170 | 906302 | 431 | 093698 | 8 |
| 53 | 797777 | 261 | 891217 | 170 | 906560 | 431 | 093440 | 7 |
| 54 | 797934 | 261 | 891115 | 170 | 906819 | 431 | 093181 | 6 |
| 55 | 798091 | 261 | 891013 | 170 | 907077 | 431 | 092923 | 5 |
| 56 | 798247 | 261 | 890911 | 170 | 907336 | 431 | 092664 | 4 |
| 57 | 798403 | 260 | 890809 | 170 | 907594 | 431 | 092406 | 3 |
| 58 | 798560 | 260 | 890707 | 170 | 907852 | 431 | 092148 | 2 |
| 59 | 798716 | 260 | 890605 | 170 | 908111 | 430 | 091889 | 1 |
| 60 | 798872 | 260 | 890503 | 170 | 908369 | 430 | 091631 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·798872 | 260 | 9·890503 | 170 | 9·908369 | 430 | 10·091631 | 60 |
| 1 | 799028 | 260 | 890400 | 171 | 908628 | 430 | 091372 | 59 |
| 2 | 799184 | 260 | 890298 | 171 | 908886 | 430 | 091114 | 58 |
| 3 | 799339 | 259 | 890195 | 171 | 909144 | 430 | 090856 | 57 |
| 4 | 799495 | 259 | 890093 | 171 | 909402 | 430 | 090598 | 56 |
| 5 | 799651 | 259 | 889990 | 171 | 909660 | 430 | 090340 | 55 |
| 6 | 799806 | 259 | 889888 | 171 | 909918 | 430 | 090082 | 54 |
| 7 | 799962 | 259 | 889785 | 171 | 910177 | 430 | 089823 | 53 |
| 8 | 800117 | 259 | 889682 | 171 | 910435 | 430 | 089565 | 52 |
| 9 | 800272 | 258 | 889579 | 171 | 910693 | 430 | 089307 | 51 |
| 10 | 800427 | 258 | 889477 | 171 | 910951 | 430 | 089049 | 50 |
| 11 | 9·800582 | 258 | 9·889374 | 172 | 9·911209 | 430 | 10·088791 | 49 |
| 12 | 800737 | 258 | 889271 | 172 | 911467 | 430 | 088533 | 48 |
| 13 | 800892 | 258 | 889168 | 172 | 911724 | 430 | 088276 | 47 |
| 14 | 801047 | 258 | 889064 | 172 | 911982 | 430 | 088018 | 46 |
| 15 | 801201 | 258 | 888961 | 172 | 912240 | 430 | 087760 | 45 |
| 16 | 801356 | 257 | 888858 | 172 | 912498 | 430 | 087502 | 44 |
| 17 | 801511 | 257 | 888755 | 172 | 912756 | 430 | 087244 | 43 |
| 18 | 801665 | 257 | 888651 | 172 | 913014 | 429 | 086986 | 42 |
| 19 | 801819 | 257 | 888548 | 172 | 913271 | 429 | 086729 | 41 |
| 20 | 801973 | 257 | 888444 | 173 | 913529 | 429 | 086471 | 40 |
| 21 | 9·802128 | 257 | 9·888341 | 173 | 9·913787 | 429 | 10·086213 | 39 |
| 22 | 802282 | 256 | 888237 | 173 | 914044 | 429 | 085956 | 38 |
| 23 | 802436 | 256 | 888134 | 173 | 914302 | 429 | 085698 | 37 |
| 24 | 802589 | 256 | 888030 | 173 | 914560 | 429 | 085440 | 36 |
| 25 | 802743 | 256 | 887926 | 173 | 914817 | 429 | 085183 | 35 |
| 26 | 802897 | 256 | 887822 | 173 | 915075 | 429 | 084925 | 34 |
| 27 | 803050 | 256 | 887718 | 173 | 915332 | 429 | 084668 | 33 |
| 28 | 803204 | 256 | 887614 | 173 | 915590 | 429 | 084410 | 32 |
| 29 | 803357 | 255 | 887510 | 173 | 915847 | 429 | 084153 | 31 |
| 30 | 803511 | 255 | 887406 | 174 | 916104 | 429 | 083896 | 30 |
| 31 | 9·803664 | 255 | 9·887302 | 174 | 9·916362 | 429 | 10·083638 | 29 |
| 32 | 803817 | 255 | 887198 | 174 | 916619 | 429 | 083381 | 28 |
| 33 | 803970 | 255 | 887093 | 174 | 916877 | 429 | 083123 | 27 |
| 34 | 804123 | 255 | 886989 | 174 | 917134 | 429 | 082866 | 26 |
| 35 | 804276 | 254 | 886885 | 174 | 917391 | 429 | 082609 | 25 |
| 36 | 804428 | 254 | 886780 | 174 | 917648 | 429 | 082352 | 24 |
| 37 | 804581 | 254 | 886676 | 174 | 917905 | 429 | 082095 | 23 |
| 38 | 804734 | 254 | 886571 | 174 | 918163 | 428 | 081837 | 22 |
| 39 | 804886 | 254 | 886466 | 174 | 918420 | 428 | 081580 | 21 |
| 40 | 805039 | 254 | 886362 | 175 | 918677 | 428 | 081323 | 20 |
| 41 | 9·805191 | 254 | 9·886257 | 175 | 9·918934 | 428 | 10·081066 | 19 |
| 42 | 805343 | 253 | 886152 | 175 | 919191 | 428 | 080809 | 18 |
| 43 | 805495 | 253 | 886047 | 175 | 919448 | 428 | 080552 | 17 |
| 44 | 805647 | 253 | 885942 | 175 | 919705 | 428 | 080295 | 16 |
| 45 | 805799 | 253 | 885837 | 175 | 919962 | 428 | 080038 | 15 |
| 46 | 805951 | 253 | 885732 | 175 | 920219 | 428 | 079781 | 14 |
| 47 | 806103 | 253 | 885627 | 175 | 920476 | 428 | 079524 | 13 |
| 48 | 806254 | 253 | 885522 | 175 | 920733 | 428 | 079267 | 12 |
| 49 | 806406 | 252 | 885416 | 175 | 920990 | 428 | 079010 | 11 |
| 50 | 806557 | 252 | 885311 | 176 | 921247 | 428 | 078753 | 10 |
| 51 | 9·806709 | 252 | 9·885205 | 176 | 9·921503 | 428 | 10·078497 | 9 |
| 52 | 806860 | 252 | 885100 | 176 | 921760 | 428 | 078240 | 8 |
| 53 | 807011 | 252 | 884994 | 176 | 922017 | 428 | 077983 | 7 |
| 54 | 807163 | 252 | 884889 | 176 | 922274 | 428 | 077726 | 6 |
| 55 | 807314 | 252 | 884783 | 176 | 922530 | 428 | 077470 | 5 |
| 56 | 807465 | 251 | 884677 | 176 | 922787 | 428 | 077213 | 4 |
| 57 | 807615 | 251 | 884572 | 176 | 923044 | 428 | 076956 | 3 |
| 58 | 807766 | 251 | 884466 | 176 | 923300 | 428 | 076700 | 2 |
| 59 | 807917 | 251 | 884360 | 176 | 923557 | 427 | 076443 | 1 |
| 60 | 808067 | 251 | 884254 | 177 | 923813 | 427 | 076187 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·808067 | 251 | 9·884254 | 177 | 9·923813 | 427 | 10·076187 | 60 |
| 1 | 808218 | 251 | 884148 | 177 | 924070 | 427 | 075930 | 59 |
| 2 | 808368 | 251 | 884042 | 177 | 924327 | 427 | 075673 | 58 |
| 3 | 808519 | 250 | 883936 | 177 | 924583 | 427 | 075417 | 57 |
| 4 | 808669 | 250 | 883829 | 177 | 924840 | 427 | 075160 | 56 |
| 5 | 808819 | 250 | 883723 | 177 | 925096 | 427 | 074904 | 55 |
| 6 | 808969 | 250 | 883617 | 177 | 925352 | 427 | 074648 | 54 |
| 7 | 809119 | 250 | 883510 | 177 | 925609 | 427 | 074391 | 53 |
| 8 | 809269 | 250 | 883404 | 177 | 925865 | 427 | 074135 | 52 |
| 9 | 809419 | 249 | 883297 | 178 | 926122 | 427 | 073878 | 51 |
| 10 | 809569 | 249 | 883191 | 178 | 926378 | 427 | 073622 | 50 |
| 11 | 9·809718 | 249 | 9·883084 | 178 | 9·926634 | 427 | 10·073366 | 49 |
| 12 | 809868 | 249 | 882977 | 178 | 926890 | 427 | 073110 | 48 |
| 13 | 810017 | 249 | 882871 | 178 | 927147 | 427 | 072853 | 47 |
| 14 | 810167 | 249 | 882764 | 178 | 927403 | 427 | 072597 | 46 |
| 15 | 810316 | 248 | 882657 | 178 | 927659 | 427 | 072341 | 45 |
| 16 | 810465 | 248 | 882550 | 178 | 927915 | 427 | 072085 | 44 |
| 17 | 810614 | 248 | 882443 | 178 | 928171 | 427 | 071829 | 43 |
| 18 | 810763 | 248 | 882336 | 179 | 928427 | 427 | 071573 | 42 |
| 19 | 810912 | 248 | 882229 | 179 | 928683 | 427 | 071317 | 41 |
| 20 | 811061 | 248 | 882121 | 179 | 928940 | 427 | 071060 | 40 |
| 21 | 9·811210 | 248 | 9·882014 | 179 | 9·929196 | 427 | 10·070804 | 39 |
| 22 | 811358 | 247 | 881907 | 179 | 929452 | 427 | 070548 | 38 |
| 23 | 811507 | 247 | 881799 | 179 | 929708 | 427 | 070292 | 37 |
| 24 | 811655 | 247 | 881692 | 179 | 929964 | 426 | 070036 | 36 |
| 25 | 811804 | 247 | 881584 | 179 | 930220 | 426 | 069780 | 35 |
| 26 | 811952 | 247 | 881477 | 179 | 930475 | 426 | 069525 | 34 |
| 27 | 812100 | 247 | 881369 | 179 | 930731 | 426 | 069269 | 33 |
| 28 | 812248 | 247 | 881261 | 180 | 930987 | 426 | 069013 | 32 |
| 29 | 812396 | 246 | 881153 | 180 | 931243 | 426 | 068757 | 31 |
| 30 | 812544 | 246 | 881046 | 180 | 931499 | 426 | 068501 | 30 |
| 31 | 9·812692 | 246 | 9·880938 | 180 | 9·931755 | 426 | 10·068245 | 29 |
| 32 | 812840 | 246 | 880830 | 180 | 932010 | 426 | 067990 | 28 |
| 33 | 812988 | 246 | 880722 | 180 | 932266 | 426 | 067734 | 27 |
| 34 | 813135 | 246 | 880613 | 180 | 932522 | 426 | 067478 | 26 |
| 35 | 813283 | 246 | 880505 | 180 | 932778 | 426 | 067222 | 25 |
| 36 | 813430 | 245 | 880397 | 180 | 933033 | 426 | 066967 | 24 |
| 37 | 813578 | 245 | 880289 | 181 | 933289 | 426 | 066711 | 23 |
| 38 | 813725 | 245 | 880180 | 181 | 933545 | 426 | 066455 | 22 |
| 39 | 813872 | 245 | 880072 | 181 | 933800 | 426 | 066200 | 21 |
| 40 | 814019 | 245 | 879963 | 181 | 934056 | 426 | 065944 | 20 |
| 41 | 9·814166 | 245 | 9·879855 | 181 | 9·934311 | 426 | 10·065689 | 19 |
| 42 | 814313 | 245 | 879746 | 181 | 934567 | 426 | 065433 | 18 |
| 43 | 814460 | 244 | 879637 | 181 | 934823 | 426 | 065177 | 17 |
| 44 | 814607 | 244 | 879529 | 181 | 935078 | 426 | 064922 | 16 |
| 45 | 814753 | 244 | 879420 | 181 | 935333 | 426 | 064667 | 15 |
| 46 | 814900 | 244 | 879311 | 181 | 935589 | 426 | 064411 | 14 |
| 47 | 815046 | 244 | 879202 | 182 | 935844 | 426 | 064156 | 13 |
| 48 | 815193 | 244 | 879093 | 182 | 936100 | 426 | 063900 | 12 |
| 49 | 815339 | 244 | 878984 | 182 | 936355 | 426 | 063645 | 11 |
| 50 | 815485 | 243 | 878875 | 182 | 936610 | 426 | 063390 | 10 |
| 51 | 9·815631 | 243 | 9·878766 | 182 | 9·936866 | 425 | 10·063134 | 9 |
| 52 | 815778 | 243 | 878656 | 182 | 937121 | 425 | 062879 | 8 |
| 53 | 815924 | 243 | 878547 | 182 | 937376 | 425 | 062624 | 7 |
| 54 | 816069 | 243 | 878438 | 182 | 937632 | 425 | 062368 | 6 |
| 55 | 816215 | 243 | 878328 | 182 | 937887 | 425 | 062113 | 5 |
| 56 | 816361 | 243 | 878219 | 183 | 938142 | 425 | 061858 | 4 |
| 57 | 816507 | 242 | 878109 | 183 | 938398 | 425 | 061602 | 3 |
| 58 | 816652 | 242 | 877999 | 183 | 938653 | 425 | 061347 | 2 |
| 59 | 816798 | 242 | 877890 | 183 | 938908 | 425 | 061092 | 1 |
| 60 | 816943 | 242 | 877780 | 183 | 939163 | 425 | 060837 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine. | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·816943 | 242 | 9 877780 | 183 | 9·939163 | 425 | 10·060837 | 60 |
| 1 | 817088 | 242 | 877670 | 183 | 939418 | 425 | 060582 | 59 |
| 2 | 817233 | 242 | 877560 | 183 | 939673 | 425 | 060327 | 58 |
| 3 | 817379 | 242 | 877450 | 183 | 939928 | 425 | 060072 | 57 |
| 4 | 817524 | 241 | 877340 | 183 | 940183 | 425 | 059817 | 56 |
| 5 | 817668 | 241 | 877230 | 184 | 940438 | 425 | 059562 | 55 |
| 6 | 817813 | 241 | 877120 | 184 | 940694 | 425 | 059306 | 54 |
| 7 | 817958 | 241 | 877010 | 184 | 940949 | 425 | 059051 | 53 |
| 8 | 818103 | 241 | 876899 | 184 | 941204 | 425 | 058796 | 52 |
| 9 | 818247 | 241 | 876789 | 184 | 941458 | 425 | 058542 | 51 |
| 10 | 818392 | 241 | 876678 | 184 | 941714 | 425 | 058286 | 50 |
| 11 | 9·818536 | 240 | 9 876568 | 184 | 9·941968 | 425 | 10·058032 | 49 |
| 12 | 818681 | 240 | 876457 | 184 | 942223 | 425 | 057777 | 48 |
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| 14 | 818969 | 240 | 876236 | 185 | 942733 | 425 | 057267 | 46 |
| 15 | 819113 | 240 | 876125 | 185 | 942988 | 425 | 057012 | 45 |
| 16 | 819257 | 240 | 876014 | 185 | 943243 | 425 | 056757 | 44 |
| 17 | 819401 | 240 | 875904 | 185 | 943498 | 425 | 056502 | 43 |
| 18 | 819545 | 239 | 875793 | 185 | 943752 | 425 | 056248 | 42 |
| 19 | 819689 | 239 | 875682 | 185 | 944007 | 425 | 055993 | 41 |
| 20 | 819832 | 239 | 875571 | 185 | 944262 | 425 | 055738 | 40 |
| 21 | 9·819976 | 239 | 9·875459 | 185 | 9·944517 | 425 | 10·055483 | 39 |
| 22 | 820120 | 239 | 875348 | 185 | 944771 | 424 | 055229 | 38 |
| 23 | 820263 | 239 | 875237 | 185 | 945026 | 424 | 054974 | 37 |
| 24 | 820406 | 239 | 875126 | 186 | 945281 | 424 | 054719 | 36 |
| 25 | 820550 | 238 | 875014 | 186 | 945535 | 424 | 054465 | 35 |
| 26 | 820693 | 238 | 874903 | 186 | 945790 | 424 | 054210 | 34 |
| 27 | 820836 | 238 | 874791 | 186 | 946045 | 424 | 053955 | 33 |
| 28 | 820979 | 238 | 874680 | 186 | 946299 | 424 | 053701 | 32 |
| 29 | 821122 | 238 | 874568 | 186 | 946554 | 424 | 053446 | 31 |
| 30 | 821265 | 238 | 874456 | 186 | 946808 | 424 | 053192 | 30 |
| 31 | 9·821407 | 238 | 9·874344 | 186 | 9·947063 | 424 | 10·052937 | 29 |
| 32 | 821550 | 238 | 874232 | 187 | 947318 | 424 | 052682 | 28 |
| 33 | 821693 | 237 | 874121 | 187 | 947572 | 424 | 052428 | 27 |
| 34 | 821835 | 237 | 874009 | 187 | 947826 | 424 | 052174 | 26 |
| 35 | 821977 | 237 | 873896 | 187 | 948081 | 424 | 051919 | 25 |
| 36 | 822120 | 237 | 873784 | 187 | 948336 | 424 | 051664 | 24 |
| 37 | 822262 | 237 | 873672 | 187 | 948590 | 424 | 051410 | 23 |
| 38 | 822404 | 237 | 873560 | 187 | 948844 | 424 | 051156 | 22 |
| 39 | 822546 | 237 | 873448 | 187 | 949099 | 424 | 050901 | 21 |
| 40 | 822688 | 236 | 873335 | 187 | 949353 | 424 | 050647 | 20 |
| 41 | 9·822830 | 236 | 9·873223 | 187 | 9·949607 | 424 | 10.050393 | 19 |
| 42 | 822972 | 236 | 873110 | 188 | 949862 | 424 | 050138 | 18 |
| 43 | 823114 | 236 | 872998 | 188 | 950116 | 424 | 049884 | 17 |
| 44 | 823255 | 236 | 872885 | 188 | 950370 | 424 | 049630 | 16 |
| 45 | 823397 | 236 | 872772 | 188 | 950625 | 424 | 049375 | 15 |
| 46 | 823539 | 236 | 872659 | 188 | 950879 | 424 | 049121 | 14 |
| 47 | 823680 | 235 | 872547 | 188 | 951133 | 424 | 048867 | 13 |
| 48 | 823821 | 235 | 872434 | 188 | 951388 | 424 | 048612 | 12 |
| 49 | 823963 | 235 | 872321 | 188 | 951642 | 424 | 048358 | 11 |
| 50 | 824104 | 235 | 872208 | 188 | 951896 | 424 | 048104 | 10 |
| 51 | 9·824245 | 235 | 9·872095 | 189 | 9·952150 | 424 | 10·047850 | 9 |
| 52 | 824386 | 235 | 871981 | 189 | 952405 | 424 | 047595 | 8 |
| 53 | 824527 | 235 | 871868 | 189 | 952659 | 424 | 047341 | 7 |
| 54 | 824668 | 234 | 871755 | 189 | 952913 | 424 | 047087 | 6 |
| 55 | 824808 | 234 | 871641 | 189 | 953167 | 423 | 046833 | 5 |
| 56 | 824949 | 234 | 871528 | 189 | 953421 | 423 | 046579 | 4 |
| 57 | 825090 | 234 | 871414 | 189 | 953675 | 423 | 046325 | 3 |
| 58 | 825230 | 234 | 871301 | 189 | 953929 | 423 | 046071 | 2 |
| 59 | 825371 | 234 | 871187 | 189 | 954183 | 423 | 045817 | 1 |
| 60 | 825511 | 234 | 871073 | 190 | 954437 | 423 | 045565 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
|---|---|---|---|---|---|---|---|---|
| 0 | 9·825511 | 234 | 9·871073 | 190 | 9·954437 | 423 | 10·045563 | 60 |
| 1 | 825651 | 233 | 870960 | 190 | 954691 | 423 | 045309 | 59 |
| 2 | 825791 | 233 | 870846 | 190 | 954945 | 423 | 045055 | 58 |
| 3 | 825931 | 233 | 870732 | 190 | 955200 | 423 | 044800 | 57 |
| 4 | 826071 | 233 | 870618 | 190 | 955454 | 423 | 044546 | 56 |
| 5 | 826211 | 233 | 870504 | 190 | 955707 | 423 | 044293 | 55 |
| 6 | 826351 | 233 | 870390 | 190 | 955961 | 423 | 044039 | 54 |
| 7 | 826491 | 233 | 870276 | 190 | 956215 | 423 | 043785 | 53 |
| 8 | 826631 | 233 | 870161 | 190 | 956469 | 423 | 043531 | 52 |
| 9 | 826770 | 232 | 870047 | 191 | 956723 | 423 | 043277 | 51 |
| 10 | 826910 | 232 | 869933 | 191 | 956977 | 423 | 043023 | 50 |
| 11 | 9·827049 | 232 | 9·869818 | 191 | 9·957231 | 423 | 10·042769 | 49 |
| 12 | 827189 | 232 | 869704 | 191 | 957485 | 423 | 042515 | 48 |
| 13 | 827328 | 232 | 869589 | 191 | 957739 | 423 | 042261 | 47 |
| 14 | 827467 | 232 | 869474 | 191 | 957993 | 423 | 042007 | 46 |
| 15 | 827606 | 232 | 869360 | 191 | 958246 | 423 | 041754 | 45 |
| 16 | 827745 | 232 | 869245 | 191 | 958500 | 423 | 041500 | 44 |
| 17 | 827884 | 231 | 869130 | 191 | 958754 | 423 | 041246 | 43 |
| 18 | 828023 | 231 | 869015 | 192 | 959008 | 423 | 040992 | 42 |
| 19 | 828162 | 231 | 868900 | 192 | 959262 | 423 | 040738 | 41 |
| 20 | 828301 | 231 | 868785 | 192 | 959516 | 423 | 040484 | 40 |
| 21 | 9·828439 | 231 | 9·868670 | 192 | 9·959769 | 423 | 10·040231 | 39 |
| 22 | 828578 | 231 | 868555 | 192 | 960023 | 423 | 039977 | 38 |
| 23 | 828716 | 231 | 868440 | 192 | 960277 | 423 | 039723 | 37 |
| 24 | 828855 | 230 | 868324 | 192 | 960531 | 423 | 039469 | 36 |
| 25 | 828993 | 230 | 868209 | 192 | 960784 | 423 | 039216 | 35 |
| 26 | 829131 | 230 | 868093 | 192 | 961038 | 423 | 038962 | 34 |
| 27 | 829269 | 230 | 867978 | 193 | 961291 | 423 | 038709 | 33 |
| 28 | 829407 | 230 | 867862 | 193 | 961545 | 423 | 038455 | 32 |
| 29 | 829545 | 230 | 867747 | 193 | 961799 | 423 | 038201 | 31 |
| 30 | 829683 | 230 | 867631 | 193 | 962052 | 423 | 037948 | 30 |
| 31 | 9·829821 | 229 | 9·867515 | 193 | 9·962306 | 423 | 10·037694 | 29 |
| 32 | 829959 | 229 | 867399 | 193 | 962560 | 423 | 037440 | 28 |
| 33 | 830097 | 229 | 867283 | 193 | 962813 | 423 | 037187 | 27 |
| 34 | 830234 | 229 | 867167 | 193 | 963067 | 423 | 036933 | 26 |
| 35 | 830372 | 229 | 867051 | 193 | 963320 | 423 | 036680 | 25 |
| 36 | 830509 | 229 | 866935 | 194 | 963574 | 423 | 036426 | 24 |
| 37 | 830646 | 229 | 866819 | 194 | 963827 | 423 | 036173 | 23 |
| 38 | 830784 | 229 | 866703 | 194 | 964081 | 423 | 035919 | 22 |
| 39 | 830921 | 228 | 866586 | 194 | 964335 | 423 | 035665 | 21 |
| 40 | 831058 | 228 | 866470 | 194 | 964588 | 422 | 035412 | 20 |
| 41 | 9·831195 | 228 | 9·866353 | 194 | 9·964842 | 422 | 10·035158 | 19 |
| 42 | 831332 | 228 | 866237 | 194 | 965095 | 422 | 034905 | 18 |
| 43 | 831469 | 228 | 866120 | 194 | 965349 | 422 | 034651 | 17 |
| 44 | 831606 | 228 | 866004 | 195 | 965602 | 422 | 034398 | 16 |
| 45 | 831742 | 228 | 865887 | 195 | 965855 | 422 | 034145 | 15 |
| 46 | 831879 | 228 | 865770 | 195 | 966109 | 422 | 033891 | 14 |
| 47 | 832015 | 227 | 865653 | 195 | 966362 | 422 | 033638 | 13 |
| 48 | 832152 | 227 | 865536 | 195 | 966616 | 422 | 033384 | 12 |
| 49 | 832288 | 227 | 865419 | 195 | 966869 | 422 | 033131 | 11 |
| 50 | 832425 | 227 | 865302 | 195 | 967123 | 422 | 032877 | 10 |
| 51 | 9·832561 | 227 | 9·865185 | 195 | 9·967376 | 422 | 10·032624 | 9 |
| 52 | 832697 | 227 | 865068 | 195 | 967629 | 422 | 032371 | 8 |
| 53 | 832833 | 227 | 864950 | 195 | 967883 | 422 | 032117 | 7 |
| 54 | 832969 | 226 | 864833 | 196 | 968136 | 422 | 031864 | 6 |
| 55 | 833105 | 226 | 864716 | 196 | 968389 | 422 | 031611 | 5 |
| 56 | 833241 | 226 | 864598 | 196 | 968643 | 422 | 031357 | 4 |
| 57 | 833377 | 226 | 864481 | 196 | 968896 | 422 | 031104 | 3 |
| 58 | 833512 | 226 | 864363 | 196 | 969149 | 422 | 030851 | 2 |
| 59 | 833648 | 226 | 864245 | 196 | 969403 | 422 | 030597 | 1 |
| 60 | 833783 | 226 | 864127 | 196 | 969656 | 422 | 030344 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D. | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·833783 | 226 | 9·864127 | 196 | 9·969656 | 422 | 10·030344 | 60 |
| 1 | 833919 | 225 | 864010 | 196 | 969909 | 422 | 030091 | 59 |
| 2 | 834054 | 225 | 863892 | 197 | 970162 | 422 | 029838 | 58 |
| 3 | 834189 | 225 | 863774 | 197 | 970416 | 422 | 029584 | 57 |
| 4 | 834325 | 225 | 863656 | 197 | 970669 | 422 | 029331 | 56 |
| 5 | 834460 | 225 | 863538 | 197 | 970922 | 422 | 029078 | 55 |
| 6 | 834595 | 225 | 863419 | 197 | 971175 | 422 | 028825 | 54 |
| 7 | 834730 | 225 | 863301 | 197 | 971429 | 422 | 028571 | 53 |
| 8 | 834865 | 225 | 863183 | 197 | 971682 | 422 | 028318 | 52 |
| 9 | 834999 | 224 | 863064 | 197 | 971935 | 422 | 028065 | 51 |
| 10 | 835134 | 224 | 862946 | 198 | 972188 | 422 | 027812 | 50 |
| 11 | 9·835269 | 224 | 9·862827 | 198 | 9·972441 | 422 | 10·027559 | 49 |
| 12 | 835403 | 224 | 862709 | 198 | 972694 | 422 | 027306 | 48 |
| 13 | 835538 | 224 | 862590 | 198 | 972948 | 422 | 027052 | 47 |
| 14 | 835672 | 224 | 862471 | 198 | 973201 | 422 | 026799 | 46 |
| 15 | 835807 | 224 | 862353 | 198 | 973454 | 422 | 026546 | 45 |
| 16 | 835941 | 224 | 862234 | 198 | 973707 | 422 | 026293 | 44 |
| 17 | 836075 | 223 | 862115 | 198 | 973960 | 422 | 026040 | 43 |
| 18 | 836209 | 223 | 861996 | 198 | 974213 | 422 | 025787 | 42 |
| 19 | 836343 | 223 | 861877 | 198 | 974466 | 422 | 025534 | 41 |
| 20 | 836477 | 223 | 861758 | 199 | 974719 | 422 | 025281 | 40 |
| 21 | 9·836611 | 223 | 9·861638 | 199 | 9·974973 | 422 | 10·025027 | 39 |
| 22 | 836745 | 223 | 861519 | 199 | 975226 | 422 | 024774 | 38 |
| 23 | 836878 | 223 | 861400 | 199 | 975479 | 422 | 024521 | 37 |
| 24 | 837012 | 222 | 861280 | 199 | 975732 | 422 | 024268 | 36 |
| 25 | 837146 | 222 | 861161 | 199 | 975985 | 422 | 024015 | 35 |
| 26 | 837279 | 222 | 861041 | 199 | 976238 | 422 | 023762 | 34 |
| 27 | 837412 | 222 | 860922 | 199 | 976491 | 422 | 023509 | 33 |
| 28 | 837546 | 222 | 860802 | 199 | 976744 | 422 | 023256 | 32 |
| 29 | 837679 | 222 | 860682 | 200 | 976997 | 422 | 023003 | 31 |
| 30 | 837812 | 222 | 860562 | 200 | 977250 | 422 | 022750 | 30 |
| 31 | 9·837945 | 222 | 9·860442 | 200 | 9·977503 | 422 | 10·022497 | 29 |
| 32 | 838078 | 221 | 860322 | 200 | 977756 | 422 | 022244 | 28 |
| 33 | 838211 | 221 | 860202 | 200 | 978009 | 422 | 021991 | 27 |
| 34 | 838344 | 221 | 860082 | 200 | 978262 | 422 | 021738 | 26 |
| 35 | 838477 | 221 | 859962 | 200 | 978515 | 422 | 021485 | 25 |
| 36 | 838610 | 221 | 859842 | 200 | 978768 | 422 | 021232 | 24 |
| 37 | 838742 | 221 | 859721 | 201 | 979021 | 422 | 020979 | 23 |
| 38 | 838875 | 221 | 859601 | 201 | 979274 | 422 | 020726 | 22 |
| 39 | 839007 | 221 | 859480 | 201 | 979527 | 422 | 020473 | 21 |
| 40 | 839140 | 220 | 859360 | 201 | 979780 | 422 | 020220 | 20 |
| 41 | 9·839272 | 220 | 9·859239 | 201 | 9·980033 | 422 | 10·019967 | 19 |
| 42 | 839404 | 220 | 859119 | 201 | 980286 | 422 | 019714 | 18 |
| 43 | 839536 | 220 | 858998 | 201 | 980538 | 422 | 019462 | 17 |
| 44 | 839668 | 220 | 858877 | 201 | 980791 | 421 | 019209 | 16 |
| 45 | 839800 | 220 | 858756 | 202 | 981044 | 421 | 018956 | 15 |
| 46 | 839932 | 220 | 858635 | 202 | 981297 | 421 | 018703 | 14 |
| 47 | 840064 | 219 | 858514 | 202 | 981550 | 421 | 018450 | 13 |
| 48 | 840196 | 219 | 858393 | 202 | 981803 | 421 | 018197 | 12 |
| 49 | 840328 | 219 | 858272 | 202 | 982056 | 421 | 017944 | 11 |
| 50 | 840459 | 219 | 858151 | 202 | 982309 | 421 | 017691 | 10 |
| 51 | 9·840591 | 219 | 9·858029 | 202 | 9·982562 | 421 | 10·017438 | 9 |
| 52 | 840722 | 219 | 857908 | 202 | 982814 | 421 | 017186 | 8 |
| 53 | 840854 | 219 | 857786 | 202 | 983067 | 421 | 016933 | 7 |
| 54 | 840985 | 219 | 857665 | 203 | 983320 | 421 | 016680 | 6 |
| 55 | 841116 | 218 | 857543 | 203 | 983573 | 421 | 016427 | 5 |
| 56 | 841247 | 218 | 857422 | 203 | 983826 | 421 | 016174 | 4 |
| 57 | 841378 | 218 | 857300 | 203 | 984079 | 421 | 015921 | 3 |
| 58 | 841509 | 218 | 857178 | 203 | 984331 | 421 | 015669 | 2 |
| 59 | 841640 | 218 | 857056 | 203 | 984584 | 421 | 015416 | 1 |
| 60 | 841771 | 218 | 856934 | 203 | 984837 | 421 | 015163 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

| M. | Sine | D | Cosine | D. | Tang. | D. | Cotang. | |
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| 0 | 9·841771 | 218 | 9·856934 | 203 | 9·984837 | 421 | 10·015163 | 60 |
| 1 | 841902 | 218 | 856812 | 203 | 985090 | 421 | 014910 | 59 |
| 2 | 842033 | 218 | 856690 | 204 | 985343 | 421 | 014657 | 58 |
| 3 | 842163 | 217 | 856568 | 204 | 985596 | 421 | 014404 | 57 |
| 4 | 842294 | 217 | 856446 | 204 | 985848 | 421 | 014152 | 56 |
| 5 | 842424 | 217 | 856323 | 204 | 986101 | 421 | 013899 | 55 |
| 6 | 842555 | 217 | 856201 | 204 | 986354 | 421 | 013646 | 54 |
| 7 | 842685 | 217 | 856078 | 204 | 986607 | 421 | 013393 | 53 |
| 8 | 842815 | 217 | 855956 | 204 | 986860 | 421 | 013140 | 52 |
| 9 | 842946 | 217 | 855833 | 204 | 987112 | 421 | 012888 | 51 |
| 10 | 843076 | 217 | 855711 | 205 | 987365 | 421 | 012635 | 50 |
| 11 | 9·843206 | 216 | 9·855588 | 205 | 9·987618 | 421 | 10·012382 | 49 |
| 12 | 843336 | 216 | 855465 | 205 | 987871 | 421 | 012129 | 48 |
| 13 | 843466 | 216 | 855342 | 205 | 988123 | 421 | 011877 | 47 |
| 14 | 843595 | 216 | 855219 | 205 | 988376 | 421 | 011624 | 46 |
| 15 | 843725 | 216 | 855096 | 205 | 988629 | 421 | 011371 | 45 |
| 16 | 843855 | 216 | 854973 | 205 | 988882 | 421 | 011118 | 44 |
| 17 | 843984 | 216 | 854850 | 205 | 989134 | 421 | 010866 | 43 |
| 18 | 844114 | 215 | 854727 | 206 | 989387 | 421 | 010613 | 42 |
| 19 | 844243 | 215 | 854603 | 206 | 989640 | 421 | 010360 | 41 |
| 20 | 844372 | 215 | 854480 | 206 | 989893 | 421 | 010107 | 40 |
| 21 | 9·844502 | 215 | 9·854356 | 206 | 9·990145 | 421 | 10·009855 | 39 |
| 22 | 844631 | 215 | 854233 | 206 | 990398 | 421 | 009602 | 38 |
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| 24 | 844889 | 215 | 853986 | 206 | 990903 | 421 | 009097 | 36 |
| 25 | 845018 | 215 | 853862 | 206 | 991156 | 421 | 008844 | 35 |
| 26 | 845147 | 215 | 853738 | 206 | 991409 | 421 | 008591 | 34 |
| 27 | 845276 | 214 | 853614 | 207 | 991662 | 421 | 008338 | 33 |
| 28 | 845405 | 214 | 853490 | 207 | 991914 | 421 | 008086 | 32 |
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| 30 | 845662 | 214 | 853242 | 207 | 992420 | 421 | 007580 | 30 |
| 31 | 9·845790 | 214 | 9·853118 | 207 | 9·992672 | 421 | 10·007328 | 29 |
| 32 | 845919 | 214 | 852994 | 207 | 992925 | 421 | 007075 | 28 |
| 33 | 846047 | 214 | 852869 | 207 | 993178 | 421 | 006822 | 27 |
| 34 | 846175 | 214 | 852745 | 207 | 993430 | 421 | 006570 | 26 |
| 35 | 846304 | 214 | 852620 | 207 | 993683 | 421 | 006317 | 25 |
| 36 | 846432 | 213 | 852496 | 208 | 993936 | 421 | 006064 | 24 |
| 37 | 846560 | 213 | 852371 | 208 | 994189 | 421 | 005811 | 23 |
| 38 | 846688 | 213 | 852247 | 208 | 994441 | 421 | 005559 | 22 |
| 39 | 846816 | 213 | 852122 | 208 | 994694 | 421 | 005306 | 21 |
| 40 | 846944 | 213 | 851997 | 208 | 994947 | 421 | 005053 | 20 |
| 41 | 9·847071 | 213 | 9·851872 | 208 | 9·995199 | 421 | 10·004801 | 19 |
| 42 | 847199 | 213 | 851747 | 208 | 995452 | 421 | 004548 | 18 |
| 43 | 847327 | 213 | 851622 | 208 | 995705 | 421 | 004295 | 17 |
| 44 | 847454 | 212 | 851497 | 209 | 995957 | 421 | 004043 | 16 |
| 45 | 847582 | 212 | 851372 | 209 | 996210 | 421 | 003790 | 15 |
| 46 | 847709 | 212 | 851246 | 209 | 996463 | 421 | 003537 | 14 |
| 47 | 847836 | 212 | 851121 | 209 | 996715 | 421 | 003285 | 13 |
| 48 | 847964 | 212 | 850996 | 209 | 996968 | 421 | 003032 | 12 |
| 49 | 848091 | 212 | 850870 | 209 | 997221 | 421 | 002779 | 11 |
| 50 | 848218 | 212 | 850745 | 209 | 997473 | 421 | 002527 | 10 |
| 51 | 9·848345 | 212 | 9·850619 | 209 | 9·997726 | 421 | 10·002274 | 9 |
| 52 | 848472 | 211 | 850493 | 210 | 997979 | 421 | 002021 | 8 |
| 53 | 848599 | 211 | 850368 | 210 | 998231 | 421 | 001769 | 7 |
| 54 | 848726 | 211 | 850242 | 210 | 998484 | 421 | 001516 | 6 |
| 55 | 848852 | 211 | 850116 | 210 | 998737 | 421 | 001263 | 5 |
| 56 | 848979 | 211 | 849990 | 210 | 998989 | 421 | 001011 | 4 |
| 57 | 849106 | 211 | 849864 | 210 | 999242 | 421 | 000758 | 3 |
| 58 | 849232 | 211 | 849738 | 210 | 999495 | 421 | 000505 | 2 |
| 59 | 849359 | 211 | 849611 | 210 | 999748 | 421 | 000253 | 1 |
| 60 | 849485 | 211 | 849485 | 210 | 10·000000 | 421 | 000000 | 0 |
| | Cosine | | Sine | | Cotang. | | Tang. | M. |

45 Degrees

# TABLE V.

# NATURAL SINES AND COSINES.

| M. | 0° Sine. | 0° Cosin. | 1° Sine | 1° Cosin. | 2° Sine. | 2° Cosin. | 3° Sine. | 3° Cosin. | 4° Sine. | 4° Cosin. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .00000 | One. | .01745 | .99985 | .03490 | .99939 | .05234 | .99863 | .06976 | .99756 | 60 |
| 1 | .00029 | One. | .01774 | .99984 | .03519 | .99938 | .05263 | .99861 | .07005 | .99754 | 59 |
| 2 | .00058 | One. | .01803 | .99984 | .03548 | .99937 | .05292 | .99860 | .07034 | .99752 | 58 |
| 3 | .00087 | One. | .01832 | .99983 | .03577 | .99936 | .05321 | .99858 | .07063 | .99750 | 57 |
| 4 | .00116 | One. | .01862 | .99983 | .03606 | .99935 | .05350 | .99857 | .07092 | .99748 | 56 |
| 5 | .0 145 | One. | .01891 | .99982 | .03635 | .99934 | .05379 | .99855 | .07121 | .99746 | 55 |
| 6 | .00175 | One. | .01920 | .99982 | .03664 | .99933 | .05408 | .99854 | .07150 | .99744 | 54 |
| 7 | .00204 | One. | .01949 | .99981 | .03693 | .99932 | .05437 | .99852 | .07179 | .99742 | 53 |
| 8 | .00233 | One. | .01978 | .99980 | .03723 | .99931 | .05466 | .99851 | .07208 | .99740 | 52 |
| 9 | .00262 | One. | .02007 | .99980 | .03752 | .99930 | .05495 | .99849 | .07237 | .99738 | 51 |
| 10 | .00291 | One. | .02036 | .99979 | .03781 | .99929 | .05524 | .99847 | .07266 | .99736 | 50 |
| 11 | .00320 | .99999 | .02065 | .99979 | .03810 | .99927 | .05553 | .99846 | .07295 | .99734 | 49 |
| 12 | .00349 | .99999 | .02094 | .99978 | .03839 | .99926 | .05582 | .99844 | .07324 | .99731 | 48 |
| 13 | .00378 | .99999 | .02123 | .99977 | .03868 | .99925 | .05611 | .99842 | .07353 | .99729 | 47 |
| 14 | .00407 | .99999 | .02152 | .99977 | .03897 | .99924 | .05640 | .99841 | .07382 | .99727 | 46 |
| 15 | .00436 | .99999 | .02181 | .99976 | .03926 | .99923 | .05669 | .99839 | .07411 | .99725 | 45 |
| 16 | .00465 | .99999 | .02211 | .99976 | .03955 | .99922 | .05698 | .99838 | .07440 | .99723 | 44 |
| 17 | .00495 | .99999 | .02240 | .99975 | .03984 | .99921 | .05727 | .99836 | .07469 | .99721 | 43 |
| 18 | .00524 | .99999 | .02269 | .99974 | .04013 | .99919 | .05756 | .99834 | .07498 | .99719 | 42 |
| 19 | .00553 | .99998 | .02298 | .99974 | .04042 | .99918 | .05785 | .99833 | .07527 | .99716 | 41 |
| 20 | .00582 | .99998 | .02327 | .99973 | .04071 | .99917 | .05814 | .99831 | .07556 | .99714 | 40 |
| 21 | .00611 | .99998 | .02356 | .99972 | .04100 | .99916 | .05844 | .99829 | .07585 | .99712 | 39 |
| 22 | .00640 | .99998 | .02385 | .99972 | .04129 | .99915 | .05873 | .99827 | .07614 | .99710 | 38 |
| 23 | .00669 | .99998 | .02414 | .99971 | .04159 | .99913 | .05902 | .99826 | .07643 | .99708 | 37 |
| 24 | .00698 | .99998 | .02443 | .99970 | .04188 | .99912 | .05931 | .99824 | .07672 | .99705 | 36 |
| 25 | .00727 | .99997 | .02472 | .99969 | .04217 | .99911 | .05960 | .99822 | .07701 | .99703 | 35 |
| 26 | .00756 | .99997 | .02501 | .99969 | .04246 | .99910 | .05989 | .99821 | .07730 | .99701 | 34 |
| 27 | .00785 | .99997 | .02530 | .99968 | .04275 | .99909 | .06018 | .99819 | .07759 | .99699 | 33 |
| 28 | .00814 | .99997 | .02560 | .99967 | .04304 | .99907 | .06047 | .99817 | .07788 | .99696 | 32 |
| 29 | .00844 | .99996 | .02589 | .99966 | .04333 | .99906 | .06076 | .99815 | .07817 | .99694 | 31 |
| 30 | .00873 | .99996 | .02618 | .99966 | .04362 | .99905 | .06105 | .99813 | .07846 | .99692 | 30 |
| 31 | .00902 | .99996 | .02647 | .99965 | .04391 | .99904 | .06134 | .99812 | .07875 | .99689 | 29 |
| 32 | .00931 | .99996 | .02676 | .99964 | .04420 | .99902 | .06163 | .99810 | .07904 | .99687 | 28 |
| 33 | .00960 | .99995 | .02705 | .99963 | .04449 | .99901 | .06192 | .99808 | .07933 | .99685 | 27 |
| 34 | .00989 | .99995 | .02734 | .99963 | .04478 | .99900 | .06221 | .99806 | .07962 | .99683 | 26 |
| 35 | .01018 | .99995 | .02763 | .99962 | .04507 | .99898 | .06250 | .99804 | .07991 | .99680 | 25 |
| 36 | .01047 | .99995 | .02792 | .99961 | .04536 | .99897 | .06279 | .99803 | .08020 | .99678 | 24 |
| 37 | .01076 | .99994 | .02821 | .99960 | .04565 | .99896 | .06308 | .99801 | .08049 | .99676 | 23 |
| 38 | .01105 | .99994 | .02850 | .99959 | .04594 | .99894 | .06337 | .99799 | .08078 | .99673 | 22 |
| 39 | .01341 | .99994 | .02879 | .99959 | .04623 | .99893 | .06366 | .99797 | .08107 | .99671 | 21 |
| 40 | .01164 | .99993 | .02908 | .99958 | .04653 | .99892 | .06395 | .99795 | .08136 | .99668 | 20 |
| 41 | .01193 | .99993 | .02938 | .99957 | .04682 | .99890 | .06424 | .99793 | .08165 | .99666 | 19 |
| 42 | .01222 | .99993 | .02967 | .99956 | .04711 | .99889 | .06453 | .99792 | .08194 | .99664 | 18 |
| 43 | .01251 | .99992 | .02996 | .99955 | .04740 | .99888 | .06482 | .99790 | .08223 | .99661 | 17 |
| 44 | .01280 | .99992 | .03025 | .99954 | .04769 | .99886 | .06511 | .99788 | .08252 | .99659 | 16 |
| 45 | .01309 | .99991 | .03054 | .99953 | .04798 | .99885 | .06540 | .99786 | .08281 | .99657 | 15 |
| 46 | .01338 | .99991 | .03083 | .99952 | .04827 | .99883 | .06569 | .99784 | .08310 | .99654 | 14 |
| 47 | .01367 | .99991 | .03112 | .99952 | .04856 | .99882 | .06598 | .99782 | .08339 | .99652 | 13 |
| 48 | .01396 | .99990 | .03141 | .99951 | .04885 | .99881 | .06627 | .99780 | .08368 | .99649 | 12 |
| 49 | .01425 | .99990 | .03170 | .99950 | .04914 | .99879 | .06656 | .99778 | .08397 | .99647 | 11 |
| 50 | .01454 | .99989 | .03199 | .99949 | .04943 | .99878 | .06685 | .99776 | .08426 | .99644 | 10 |
| 51 | .01483 | .99989 | .03228 | .99948 | .04972 | .99876 | .06714 | .99774 | .08455 | .99642 | 9 |
| 52 | .01513 | .99989 | .03257 | .99947 | .05001 | .99875 | .06743 | .99772 | .08484 | .99639 | 8 |
| 53 | .01542 | .99988 | .03286 | .99946 | .05030 | .99873 | .06773 | .99770 | .08513 | .99637 | 7 |
| 54 | .01571 | .99988 | .03316 | .99945 | .05059 | .99872 | .06802 | .99768 | .08542 | .99635 | 6 |
| 55 | .01600 | .99987 | .03345 | .99944 | .05088 | .99870 | .06831 | .99766 | .08571 | .99632 | 5 |
| 56 | .01629 | .99987 | .03374 | .99943 | .05117 | .99869 | .06860 | .99764 | .08600 | .99630 | 4 |
| 57 | .01658 | .99986 | .03403 | .99942 | .05146 | .99867 | .06889 | .99762 | .08629 | .99627 | 3 |
| 58 | .01687 | .99986 | .03432 | .99941 | .05175 | .99866 | .06918 | .99760 | .08658 | .99625 | 2 |
| 59 | .01716 | .99985 | .03461 | .99940 | .05205 | .99864 | .06947 | .99758 | .08687 | .99622 | 1 |
| 60 | .01745 | .99985 | .03490 | .99939 | .05234 | .99863 | .06976 | .99756 | .08716 | .99619 | 0 |
| M. | Cosin. | Sine. | Cosin. | Sine | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | M. |
| | 89° | | 88° | | 87° | | 86° | | 85° | | |

| M. | 5° Sine. | 5° Cosin. | 6° Sine. | 6° Cosin. | 7° Sine. | 7° Cosin. | 8° Sine | 8° Cosin. | 9° Sine. | 9° Cosin. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .08716 | .99619 | .10453 | .99452 | .12187 | .99255 | .13917 | .99027 | .15643 | .98769 | 60 |
| 1 | .08745 | .99617 | .10482 | .99449 | .12216 | .99251 | .13946 | .99023 | .15672 | .98764 | 59 |
| 2 | .08774 | .99614 | .10511 | .99446 | .12245 | .99248 | .13975 | .99019 | .15701 | .98760 | 58 |
| 3 | .08803 | .99612 | .10540 | .99443 | .12274 | .99244 | .14004 | .99015 | .15730 | .98755 | 57 |
| 4 | .08831 | .99609 | .10569 | .99440 | .12302 | .99240 | .14033 | .99011 | .15758 | .98751 | 56 |
| 5 | .08860 | .99607 | .10597 | .99437 | .12331 | .99237 | .14061 | .99006 | .15787 | .98746 | 55 |
| 6 | .08889 | .99604 | .10626 | .99434 | .12360 | .99233 | .14090 | .99002 | .15816 | .98741 | 54 |
| 7 | .08918 | .99602 | .10655 | .99431 | .12389 | .99230 | .14119 | .98998 | .15845 | .98737 | 53 |
| 8 | .08947 | .99599 | .10684 | .99428 | .12418 | .99226 | .14148 | .98994 | .15873 | .98732 | 52 |
| 9 | .08976 | .99596 | .10713 | .99424 | .12447 | .99222 | .14177 | .98990 | .15902 | .98728 | 51 |
| 10 | .09005 | .99594 | .10742 | .99421 | .12476 | .99219 | .14205 | .98986 | .15931 | .98723 | 50 |
| 11 | .09034 | .99591 | .10771 | .99418 | .12504 | .99215 | .14234 | .98982 | .15959 | .98718 | 49 |
| 12 | .09063 | .99588 | .10800 | .99415 | .12533 | .99211 | .14263 | .98978 | .15988 | .98714 | 48 |
| 13 | .09092 | .99586 | .10829 | .99412 | .12562 | .99208 | .14292 | .98972 | .16017 | .98709 | 47 |
| 14 | .09121 | .99583 | .10858 | .99409 | .12591 | .99204 | .14320 | .98969 | .16046 | .98704 | 46 |
| 15 | .09150 | .99580 | .10887 | .99406 | .12620 | .99200 | .14349 | .98965 | .16074 | .98700 | 45 |
| 16 | .09179 | .99578 | .10916 | .99402 | .12649 | .99197 | .14378 | .98961 | .16103 | .98695 | 44 |
| 17 | .09208 | .99575 | .10945 | .99399 | .12678 | .99193 | .14407 | .98957 | .16132 | .98690 | 43 |
| 18 | .09237 | .99572 | .10973 | .99396 | .12706 | .99189 | .14436 | .98953 | .16160 | .98686 | 42 |
| 19 | .09266 | .99570 | .11002 | .99393 | .12735 | .99186 | .14464 | .98948 | .16189 | .98681 | 41 |
| 20 | .09295 | .99567 | .11031 | .99390 | .12764 | .99182 | .14493 | .98944 | .16218 | .98676 | 40 |
| 21 | .09324 | .99564 | .11060 | .99386 | .12793 | .99178 | .14522 | .98940 | .16246 | .98671 | 39 |
| 22 | .09353 | .99562 | .11089 | .99383 | .12822 | .99175 | .14551 | .98936 | .16275 | .98667 | 38 |
| 23 | .09382 | .99559 | .11118 | .99380 | .12851 | .99171 | .14580 | .98931 | .16304 | .98662 | 37 |
| 24 | .09411 | .99556 | .11147 | .99377 | .12880 | .99167 | .14608 | .98927 | .16333 | .98657 | 36 |
| 25 | .09440 | .99553 | .11176 | .99374 | .12908 | .99163 | .14637 | .98923 | .16361 | .98652 | 35 |
| 26 | .09469 | .99551 | .11205 | .99370 | .12937 | .99160 | .14666 | .98919 | .16390 | .98648 | 34 |
| 27 | .09498 | .99548 | .11234 | .99367 | .12966 | .99156 | .14695 | .98914 | .16419 | .98643 | 33 |
| 28 | .09527 | .99545 | .11263 | .99364 | .12995 | .99152 | .14723 | .98910 | .16447 | .98638 | 32 |
| 29 | .09556 | .99542 | .11291 | .99360 | .13024 | .99148 | .14752 | .98906 | .16476 | .98633 | 31 |
| 30 | .09585 | .99540 | .11320 | .99357 | .13053 | .99144 | .14781 | .98902 | .16505 | .98629 | 30 |
| 31 | .09614 | .99537 | .11349 | .99354 | .13081 | .99141 | .14810 | .98897 | .16533 | .98624 | 29 |
| 32 | .09642 | .99534 | .11378 | .99351 | .13110 | .99137 | .14838 | .98893 | .16562 | .98619 | 28 |
| 33 | .09671 | .99531 | .11407 | .99347 | .13139 | .99133 | .14867 | .98889 | .16591 | .98614 | 27 |
| 34 | .09700 | .99528 | .11436 | .99344 | .13168 | .99129 | .14896 | .98884 | .16620 | .98609 | 26 |
| 35 | .09729 | .99526 | .11465 | .99341 | .13197 | .99125 | .14925 | .98880 | .16648 | .98604 | 25 |
| 36 | .09758 | .99523 | .11494 | .99337 | .13226 | .99122 | .14954 | .98876 | .16677 | .98600 | 24 |
| 37 | .09787 | .99520 | .11523 | .99334 | .13254 | .99118 | .14982 | .98871 | .16706 | .98595 | 23 |
| 38 | .09816 | .99517 | .11552 | .99331 | .13283 | .99114 | .15011 | .98867 | .16734 | .98590 | 22 |
| 39 | .09845 | .99514 | .11580 | .99327 | .13312 | .99110 | .15040 | .98863 | .16763 | .98585 | 21 |
| 40 | .09874 | .99511 | .11609 | .99324 | .13341 | .99106 | .15069 | .98858 | .16792 | .98580 | 20 |
| 41 | .09903 | .99508 | .11638 | .99320 | .13370 | .99102 | .15097 | .98854 | .16820 | .98575 | 19 |
| 42 | .09932 | .99506 | .11667 | .99317 | .13399 | .99098 | .15126 | .98849 | .16849 | .98570 | 18 |
| 43 | .09961 | .99503 | .11696 | .99314 | .13427 | .99094 | .15155 | .98845 | .16878 | .98565 | 17 |
| 44 | .09990 | .99500 | .11725 | .99310 | .13456 | .99091 | .15184 | .98841 | .16906 | .98561 | 16 |
| 45 | .10019 | .99497 | .11754 | .99307 | .13485 | .99087 | .15212 | .98836 | .16935 | .98556 | 15 |
| 46 | .10048 | .99494 | .11783 | .99303 | .13514 | .99083 | .15241 | .98832 | .16964 | .98551 | 14 |
| 47 | .10077 | .99491 | .11812 | .99300 | .13543 | .99079 | .15270 | .98827 | .16992 | .98546 | 13 |
| 48 | .10106 | .99488 | .11840 | .99297 | .13572 | .99075 | .15299 | .98823 | .17021 | .98541 | 12 |
| 49 | .10135 | .99485 | .11869 | .99293 | .13600 | .99071 | .15327 | .98818 | .17050 | .98536 | 11 |
| 50 | .10164 | .99482 | .11898 | .99290 | .13629 | .99067 | .15356 | .98814 | .17078 | .98531 | 10 |
| 51 | .10192 | .99479 | .11927 | .99286 | .13658 | .99063 | .15385 | .98809 | .17107 | .98526 | 9 |
| 52 | .10221 | .99476 | .11956 | .99283 | .13687 | .99059 | .15414 | .98805 | .17136 | .98521 | 8 |
| 53 | .10250 | .99473 | .11985 | .99279 | .13716 | .99055 | .15442 | .98800 | .17164 | .98516 | 7 |
| 54 | .10279 | .99470 | .12014 | .99276 | .13744 | .99051 | .15471 | .98796 | .17193 | .98511 | 6 |
| 55 | .10308 | .99467 | .12043 | .99272 | .13773 | .99047 | .15500 | .98791 | .17222 | .98506 | 5 |
| 56 | .10337 | .99464 | .12071 | .99269 | .13802 | .99043 | .15529 | .98787 | .17250 | .98501 | 4 |
| 57 | .10366 | .99461 | .12100 | .99265 | .13831 | .99039 | .15557 | .98782 | .17279 | .98496 | 3 |
| 58 | .10395 | .99458 | .12129 | .99262 | .13860 | .99035 | .15586 | .98778 | .17308 | .98491 | 2 |
| 59 | .10424 | .99455 | .12158 | .99258 | .13889 | .99031 | .15615 | .98773 | .17336 | .98486 | 1 |
| 60 | .10453 | .99452 | .12187 | .99255 | .13917 | .99027 | .15643 | .98769 | .17365 | .98481 | 0 |
| M. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | M. |
| | 84° | | 83° | | 82° | | 81° | | 80° | | |

| M. | 10° Sine | 10° Cosin. | 11° Sine. | 11° Cosin. | 12° Sine | 12° Cosin | 13° Sine. | 13° Cosin. | 14° Sine. | 14° Cosin. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .17365 | .98481 | .19081 | .98163 | .20791 | .97815 | .22495 | .97437 | .24192 | .97030 | 60 |
| 1 | .17393 | .98476 | .19109 | .98157 | .20820 | .97809 | .22523 | .97430 | .24220 | .97023 | 59 |
| 2 | .17422 | .98471 | .19138 | .98152 | .20848 | .97803 | .22552 | .97424 | .24249 | .97015 | 58 |
| 3 | .17451 | .98466 | .19167 | .98146 | .20877 | .97797 | .22580 | .97417 | .24277 | .97008 | 57 |
| 4 | .17479 | .98461 | .19195 | .98140 | .20905 | .97791 | .22608 | .97411 | .24305 | .97001 | 56 |
| 5 | .17508 | .98455 | .19224 | .98135 | .20933 | .97784 | .22637 | .97404 | .24333 | .96994 | 55 |
| 6 | .17537 | .98450 | .19252 | .98129 | .20962 | .97778 | .22665 | .97398 | .24362 | .96987 | 54 |
| 7 | .17565 | .98445 | .19281 | .98124 | .20990 | .97772 | .22693 | .97391 | .24389 | .96980 | 53 |
| 8 | .17594 | .98440 | .19309 | .98118 | .21019 | .97766 | .22722 | .97384 | .24418 | .96973 | 52 |
| 9 | .17623 | .98435 | .19338 | .98112 | .21047 | .97760 | .22750 | .97378 | .24446 | .96966 | 51 |
| 10 | .17651 | .98430 | .19366 | .98107 | .21076 | .97754 | .22778 | .97371 | .24474 | .96959 | 50 |
| 11 | .17680 | .98425 | .19395 | .98101 | .21104 | .97748 | .22807 | .97365 | .24503 | .96952 | 49 |
| 12 | .17708 | .98420 | .19423 | .98096 | .21132 | .97742 | .22835 | .97358 | .24531 | .96945 | 48 |
| 13 | .17737 | .98414 | .19452 | .98090 | .21161 | .97735 | .22863 | .97351 | .24559 | .96937 | 47 |
| 14 | .17766 | .98409 | .19481 | .98084 | .21189 | .97729 | .22892 | .97345 | .24587 | .96930 | 46 |
| 15 | .17794 | .98404 | .19509 | .98079 | .21218 | .97723 | .22920 | .97338 | .24615 | .96923 | 45 |
| 16 | .17823 | .98399 | .19538 | .98073 | .21246 | .97717 | .22948 | .97331 | .24644 | .96916 | 44 |
| 17 | .17852 | .98394 | .19566 | .98067 | .21275 | .97711 | .22977 | .97325 | .24672 | .96909 | 43 |
| 18 | .17880 | .98389 | .19595 | .98061 | .21303 | .97705 | .23005 | .97318 | .24700 | .96902 | 42 |
| 19 | .17909 | .98383 | .19623 | .98056 | .21331 | .97698 | .23033 | .97311 | .24728 | .96894 | 41 |
| 20 | .17937 | .98378 | .19652 | .98050 | .21360 | .97692 | .23062 | .97304 | .24756 | .96887 | 40 |
| 21 | .17966 | .98373 | .19680 | .98044 | .21388 | .97686 | .23090 | .97298 | .24784 | .96880 | 39 |
| 22 | .17995 | .98368 | .19709 | .98039 | .21417 | .97680 | .23118 | .97291 | .24813 | .96873 | 38 |
| 23 | .18023 | .98362 | .19737 | .98033 | .21445 | .97673 | .23146 | .97284 | .24841 | .96866 | 37 |
| 24 | .18052 | .98357 | .19766 | .98027 | .21474 | .97667 | .23175 | .97278 | .24869 | .96858 | 36 |
| 25 | .18081 | .98352 | .19794 | .98021 | .21502 | .97661 | .23203 | .97271 | .24897 | .96851 | 35 |
| 26 | .18109 | .98347 | .19823 | .98016 | .21530 | .97655 | .23231 | .97264 | .24925 | .96844 | 34 |
| 27 | .18138 | .98341 | .19851 | .98010 | .21559 | .97648 | .23260 | .97257 | .24954 | .96837 | 33 |
| 28 | .18166 | .98336 | .19880 | .98004 | .21587 | .97642 | .23288 | .97251 | .24982 | .96829 | 32 |
| 29 | .18195 | .98331 | .19908 | .97998 | .21616 | .97636 | .23316 | .97244 | .25010 | .96822 | 31 |
| 30 | .18224 | .98325 | .19937 | .97992 | .21644 | .97630 | .23345 | .97237 | .25038 | .96815 | 30 |
| 31 | .18252 | .98320 | .19965 | .97987 | .21672 | .97623 | .23373 | .97230 | .25066 | .96807 | 29 |
| 32 | .18281 | .98315 | .19994 | .97981 | .21701 | .97617 | .23401 | .97223 | .25094 | .96800 | 28 |
| 33 | .18309 | .98310 | .20022 | .97975 | .21729 | .97611 | .23429 | .97217 | .25122 | .96793 | 27 |
| 34 | .18338 | .98304 | .20051 | .97969 | .21758 | .97604 | .23458 | .97210 | .25151 | .96786 | 26 |
| 35 | .18367 | .98299 | .20079 | .97963 | .21786 | .97598 | .23486 | .97203 | .25179 | .96778 | 25 |
| 36 | .18395 | .98294 | .20108 | .97958 | .21814 | .97592 | .23514 | .97196 | .25207 | .96771 | 24 |
| 37 | .18424 | .98288 | .20136 | .97952 | .21843 | .97585 | .23542 | .97189 | .25235 | .96764 | 23 |
| 38 | .18452 | .98283 | .20165 | .97946 | .21871 | .97579 | .23571 | .97182 | .25263 | .96756 | 22 |
| 39 | .18481 | .98277 | .20193 | .97940 | .21899 | .97573 | .23599 | .97176 | .25291 | .96749 | 21 |
| 40 | .18509 | .98272 | .20222 | .97934 | .21928 | .97566 | .23627 | .97169 | .25320 | .96742 | 20 |
| 41 | .18538 | .98267 | .20250 | .97928 | .21956 | .97560 | .23656 | .97162 | .25348 | .96734 | 19 |
| 42 | .18567 | .98261 | .20279 | .97922 | .21985 | .97553 | .23684 | .97155 | .25376 | .96727 | 18 |
| 43 | .18595 | .98256 | .20307 | .97916 | .22013 | .97547 | .23712 | .97148 | .25404 | .96719 | 17 |
| 44 | .18624 | .98250 | .20336 | .97910 | .22041 | .97541 | .23740 | .97141 | .25432 | .96712 | 16 |
| 45 | .18652 | .98245 | .20364 | .97905 | .22070 | .97534 | .23769 | .97134 | .25460 | .96705 | 15 |
| 46 | .18681 | .98240 | .20393 | .97899 | .22098 | .97528 | .23797 | .97127 | .25488 | .96697 | 14 |
| 47 | .18710 | .98234 | .20421 | .97893 | .22126 | .97521 | .23825 | .97120 | .25516 | .96690 | 13 |
| 48 | .18738 | .98229 | .20450 | .97887 | .22155 | .97515 | .23853 | .97113 | .25545 | .96682 | 12 |
| 49 | .18767 | .98223 | .20478 | .97881 | .22183 | .97508 | .23882 | .97106 | .25573 | .96675 | 11 |
| 50 | .18795 | .98218 | .20507 | .97875 | .22212 | .97502 | .23910 | .97100 | .25601 | .96667 | 10 |
| 51 | .18824 | .98212 | .20535 | .97869 | .22240 | .97496 | .23938 | .97093 | .25629 | .96660 | 9 |
| 52 | .18852 | .98207 | .20563 | .97863 | .22268 | .97489 | .23966 | .97086 | .25657 | .96653 | 8 |
| 53 | .18881 | .98201 | .20592 | .97857 | .22297 | .97483 | .23995 | .97079 | .25685 | .96645 | 7 |
| 54 | .18910 | .98196 | .20620 | .97851 | .22325 | .97476 | .24023 | .97072 | .25713 | .96638 | 6 |
| 55 | .18938 | .98190 | .20649 | .97845 | .22353 | .97470 | .24051 | .97065 | .25741 | .96630 | 5 |
| 56 | .18967 | .98185 | .20677 | .97839 | .22382 | .97463 | .24079 | .97058 | .25769 | .96623 | 4 |
| 57 | .18995 | .98179 | .20706 | .97833 | .22410 | .97457 | .24108 | .97051 | .25798 | .96615 | 3 |
| 58 | .19024 | .98174 | .20734 | .97827 | .22438 | .97450 | .24136 | .97044 | .25826 | .96608 | 2 |
| 59 | .19052 | .98168 | .20763 | .97821 | .22467 | .97444 | .24164 | .97037 | .25854 | .96600 | 1 |
| 60 | .19081 | .98163 | .20791 | .97815 | .22496 | .97437 | .24192 | .97030 | .25882 | .96593 | 0 |
| M. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | M. |
| | 79° | | 78° | | 77° | | 76° | | 75° | | |

| M. | 15° Sine. | 15° Cosin. | 16° Sine. | 16° Cosin. | 17° Sine. | 17° Cosin | 18° Sine. | 18° Cosin. | 19° Sine. | 19° Co in. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .25882 | .96593 | .27564 | .96126 | .29237 | .95630 | .30902 | .95106 | .32557 | .94552 | 60 |
| 1 | .25910 | .96585 | .27592 | .96118 | .29265 | .95622 | .30929 | .95097 | .32584 | .94542 | 59 |
| 2 | .25938 | .96578 | .27620 | .96110 | .29293 | .95613 | .30957 | .95088 | .32612 | .94533 | 58 |
| 3 | .25966 | .96570 | .27648 | .96102 | .29321 | .95605 | .30985 | .95079 | .32639 | .94523 | 57 |
| 4 | .25994 | .96562 | .27676 | .96094 | .29348 | .95596 | .31012 | .95070 | .32667 | .94514 | 56 |
| 5 | .26022 | .96555 | .27704 | .96086 | .29376 | .95588 | .31040 | .95061 | .32694 | .94504 | 55 |
| 6 | .26050 | .96547 | .27731 | .96078 | .29404 | .95579 | .31068 | .95052 | .32722 | .94495 | 54 |
| 7 | .26079 | .96540 | .27759 | .96070 | .29432 | .95571 | .31095 | .95043 | .32749 | .94485 | 53 |
| 8 | .26107 | .96532 | .27787 | .96062 | .29460 | .95562 | .31123 | .95033 | .32777 | .94476 | 52 |
| 9 | .26135 | .96524 | .27815 | .96054 | .29487 | .95554 | .31151 | .95024 | .32804 | .94466 | 51 |
| 10 | .26163 | .96517 | .27843 | .96046 | .29515 | .95545 | .31178 | .95015 | .32832 | .94457 | 50 |
| 11 | .26191 | .96509 | .27871 | .96037 | .29543 | .95536 | .31206 | .95006 | .32859 | .94447 | 49 |
| 12 | .26219 | .96502 | .27899 | .96029 | .29571 | .95528 | .31223 | .94997 | .32887 | .94438 | 48 |
| 13 | .26247 | .96494 | .27927 | .96021 | .29599 | .95519 | .31261 | .94988 | .32914 | .94428 | 47 |
| 14 | .26275 | .96486 | .27955 | .96013 | .29626 | .95511 | .31289 | .94979 | .32942 | .94418 | 46 |
| 15 | .26303 | .96479 | .27983 | .96005 | .29654 | .95502 | .31316 | .94970 | .32969 | .94409 | 45 |
| 16 | .26331 | .96471 | .28011 | .95997 | .29682 | .95493 | .31344 | .94961 | .32997 | .94399 | 44 |
| 17 | .26359 | .96463 | .28039 | .95989 | .29710 | .95485 | .31372 | .94952 | .33024 | .94390 | 43 |
| 18 | .26387 | .96456 | .28067 | .95981 | .29737 | .95476 | .31399 | .94943 | .33051 | .94380 | 42 |
| 19 | .26415 | .96448 | .28095 | .95972 | .29765 | .95467 | .31427 | .94933 | .33079 | .94370 | 41 |
| 20 | .26443 | .96440 | .28123 | .95964 | .29793 | .95459 | .31454 | .94924 | .33106 | .94361 | 40 |
| 21 | .26471 | .96433 | .28150 | .95956 | .29821 | .95450 | .31482 | .94915 | .33134 | .94351 | 39 |
| 22 | .26500 | .96425 | .28178 | .95948 | .29849 | .95441 | .31510 | .94906 | .33161 | .94342 | 38 |
| 23 | .26528 | .96417 | .28206 | .95940 | .29876 | .95433 | .31537 | .94897 | .33189 | .94332 | 37 |
| 24 | .26556 | .96410 | .28234 | .95931 | .29904 | .95424 | .31565 | .94888 | .33216 | .94322 | 36 |
| 25 | .26584 | .96402 | .28262 | .95923 | .29932 | .95415 | .31593 | .94878 | .33244 | .94313 | 35 |
| 26 | .26612 | .96394 | .28290 | .95915 | .29960 | .95407 | .31620 | .94869 | .33271 | .94303 | 34 |
| 27 | .26640 | .96386 | .28318 | .95907 | .29987 | .95398 | .31648 | .94860 | .33298 | .94293 | 33 |
| 28 | .26668 | .96379 | .28346 | .95898 | .30015 | .95389 | .31675 | .94851 | .33326 | .94284 | 32 |
| 29 | .26696 | .96371 | .28374 | .95890 | .30043 | .95380 | .31703 | .94842 | .33353 | .94274 | 31 |
| 30 | .26724 | .96363 | .28402 | .95882 | .30071 | .95372 | .31730 | .94832 | .33381 | .94264 | 30 |
| 31 | .26752 | .96355 | .28429 | .95874 | .30098 | .95363 | .31758 | .94823 | .33408 | .94254 | 29 |
| 32 | .26780 | .96347 | .28457 | .95865 | .30126 | .95354 | .31786 | .94814 | .33426 | .94245 | 28 |
| 33 | .26808 | .96340 | .28485 | .95857 | .30154 | .95345 | .31813 | .94805 | .33468 | .94235 | 27 |
| 34 | .26836 | .96332 | .28513 | .95849 | .30182 | .95337 | .31841 | .94795 | .33440 | .94225 | 26 |
| 35 | .26864 | .96324 | .28541 | .95841 | .30209 | .95328 | .31868 | .94786 | .33518 | .94215 | 25 |
| 36 | .26892 | .96316 | .28569 | .95832 | .30237 | .95319 | .31896 | .94777 | .33545 | .94206 | 24 |
| 37 | .26920 | .96308 | .28597 | .95824 | .30265 | .95310 | .31923 | .94768 | .33573 | .94196 | 23 |
| 38 | .26948 | .96301 | .28625 | .95816 | .30292 | .95301 | .31951 | .94758 | .33600 | .94186 | 22 |
| 39 | .26976 | .96293 | .28652 | .95807 | .30320 | .95293 | .31979 | .94749 | .33627 | .94176 | 21 |
| 40 | .27004 | .96285 | .28680 | .95799 | .30348 | .95284 | .32006 | .94740 | .33655 | .94167 | 20 |
| 41 | .27032 | .96277 | .28708 | .95791 | .30376 | .95275 | .32034 | .94730 | .33682 | .94157 | 19 |
| 42 | .27060 | .96269 | .28736 | .95782 | .30403 | .95266 | .32061 | .94721 | .33710 | .94147 | 18 |
| 43 | .27088 | .96261 | .28764 | .95774 | .30431 | .95257 | .32089 | .94711 | .33737 | .94137 | 17 |
| 44 | .27116 | .96253 | .28792 | .95766 | .30459 | .95248 | .32116 | .94702 | .33764 | .94127 | 16 |
| 45 | .27144 | .96246 | .28820 | .95757 | .30486 | .95240 | .32144 | .94693 | .33792 | .94118 | 15 |
| 46 | .27172 | .96238 | .28847 | .95749 | .30514 | .95231 | .32171 | .94684 | .33819 | .94108 | 14 |
| 47 | .27200 | .96230 | .28875 | .95740 | .30542 | .95222 | .32199 | .94674 | .33846 | .94098 | 13 |
| 48 | .27228 | .96222 | .28903 | .95732 | .30570 | .95213 | .32227 | .94665 | .33874 | .94088 | 12 |
| 49 | .27256 | .96214 | .28931 | .95724 | .30597 | .95204 | .32254 | .94656 | .33901 | .94078 | 11 |
| 50 | .27284 | .96206 | .28959 | .95715 | .30625 | .95195 | .32282 | .94646 | .33929 | .94068 | 10 |
| 51 | .27312 | .96198 | .28987 | .95707 | .30653 | .95186 | .32309 | .94637 | .33956 | .94058 | 9 |
| 52 | .27340 | .96190 | .29015 | .95698 | .30680 | .95177 | .32337 | .94627 | .33983 | .94049 | 8 |
| 53 | .27368 | .96182 | .29042 | .95690 | .30708 | .95168 | .32364 | .94618 | .34011 | .94039 | 7 |
| 54 | .27396 | .96174 | .29070 | .95681 | .30736 | .95159 | .32392 | .94609 | .34038 | .94029 | 6 |
| 55 | .27424 | .96166 | .29098 | .95673 | .30763 | .95150 | .32419 | .94599 | .34065 | .94019 | 5 |
| 56 | .27452 | .96158 | .29126 | .95664 | .30791 | .95142 | .32447 | .94590 | .34093 | .94009 | 4 |
| 57 | .27480 | .96150 | .29154 | .95656 | .30819 | .95133 | .32474 | .94580 | .34120 | .93999 | 3 |
| 58 | .27508 | .96142 | .29182 | .95647 | .30846 | .95124 | .32502 | .94571 | .34147 | .93989 | 2 |
| 59 | .27536 | .96134 | .29209 | .95639 | .30874 | .95115 | .32529 | .94561 | .34175 | .93979 | 1 |
| 60 | .27564 | .96126 | .29237 | .95630 | .30902 | .95106 | .32557 | .94552 | .34202 | .93969 | 0 |
| M. | Cosin | Sine. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | Cosin | Sine. | M. |
| | 74° | | 73° | | 72° | | 71° | | 70° | | |

| M. | 20° Sine. | 20° Cosin. | 21° Sine. | 21° Cosin. | 22° Sine. | 22° Cosin | 23° Sine. | 23° Cosin. | 24° Sine. | 24° Co-in. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .34202 | .93969 | .35837 | .93358 | .37461 | .92718 | .39073 | .92050 | .40674 | .91355 | 60 |
| 1 | .34229 | .93959 | .35864 | .93348 | .37488 | .92707 | .39100 | .92039 | .40700 | .91343 | 59 |
| 2 | .34257 | .93949 | .35891 | .93337 | .37515 | .92697 | .39127 | .92028 | .40727 | .91331 | 58 |
| 3 | .34284 | .93939 | .35918 | .93327 | .37542 | .92686 | .39153 | .92016 | .40753 | .91319 | 57 |
| 4 | .34311 | .93929 | .35945 | .93316 | .37569 | .92675 | .39180 | .92005 | .40780 | .91307 | 56 |
| 5 | .34339 | .93919 | .35973 | .93306 | .37595 | .92664 | .39207 | .91994 | .40806 | .91295 | 55 |
| 6 | .34366 | .93909 | .36000 | .93295 | .37622 | .92653 | .39234 | .91982 | .40833 | .91283 | 54 |
| 7 | .34393 | .93899 | .36027 | .93285 | .37649 | .92642 | .39260 | .91971 | .40860 | .91272 | 53 |
| 8 | .34421 | .93889 | .36054 | .93274 | .37676 | .92631 | .39287 | .91959 | .40886 | .91260 | 52 |
| 9 | .34448 | .93879 | .36081 | .93264 | .37703 | .92620 | .39314 | .91948 | .40913 | .91248 | 51 |
| 10 | .34475 | .93869 | .36108 | .93253 | .37730 | .92609 | .39341 | .91936 | .40939 | .91236 | 50 |
| 11 | .34503 | .93859 | .36135 | .93243 | .37757 | .92598 | .39367 | .91925 | .40966 | .91224 | 49 |
| 12 | .34530 | .93849 | .36162 | .93232 | .37784 | .92587 | .39394 | .91914 | .40992 | .91212 | 48 |
| 13 | .34557 | .93839 | .36190 | .93222 | .37811 | .92576 | .39421 | .91902 | .41019 | .91200 | 47 |
| 14 | .34584 | .93829 | .36217 | .93211 | .37838 | .92565 | .39448 | .91891 | .41045 | .91188 | 46 |
| 15 | .34612 | .93819 | .36244 | .93201 | .37865 | .92554 | .39474 | .91879 | .41072 | .91176 | 45 |
| 16 | .34639 | .93809 | .36271 | .93190 | .37892 | .92543 | .39501 | .91868 | .41098 | .91164 | 44 |
| 17 | .34666 | .93799 | .36298 | .93180 | .37919 | .92532 | .39528 | .91856 | .41125 | .91152 | 43 |
| 18 | .34694 | .93789 | .36325 | .93169 | .37946 | .92521 | .39555 | .91845 | .41151 | .91140 | 42 |
| 19 | .34721 | .93779 | .36352 | .93159 | .37973 | .92510 | .39581 | .91833 | .41178 | .91128 | 41 |
| 20 | .34748 | .93769 | .36379 | .93148 | .37999 | .92499 | .39608 | .91822 | .41204 | .91116 | 40 |
| 21 | .34775 | .93759 | .36406 | .93137 | .38026 | .92488 | .39635 | .91810 | .41231 | .91104 | 39 |
| 22 | .34803 | .93748 | .36434 | .93127 | .38053 | .92477 | .39661 | .91799 | .41257 | .91092 | 38 |
| 23 | .34830 | .93738 | .36461 | .93116 | .38080 | .92466 | .39688 | .91787 | .41284 | .91080 | 37 |
| 24 | .34857 | .93728 | .36488 | .93106 | .38107 | .92455 | .39715 | .91775 | .41310 | .91068 | 36 |
| 25 | .34884 | .93718 | .36515 | .93095 | .38134 | .92444 | .39741 | .91764 | .41337 | .91056 | 35 |
| 26 | .34912 | .93708 | .36542 | .93084 | .38161 | .92432 | .39768 | .91752 | .41363 | .91044 | 34 |
| 27 | .34939 | .93698 | .36569 | .93074 | .38188 | .92421 | .39795 | .91741 | .41390 | .91032 | 33 |
| 28 | .34966 | .93688 | .36596 | .93063 | .38215 | .92410 | .39822 | .91729 | .41416 | .91020 | 32 |
| 29 | .34993 | .93677 | .36623 | .93052 | .38241 | .92399 | .39848 | .91718 | .41443 | .91008 | 31 |
| 30 | .35021 | .93667 | .36650 | .93042 | .38268 | .92388 | .39875 | .91706 | .41469 | .90996 | 30 |
| 31 | .35048 | .93657 | .36677 | .93031 | .38295 | .92377 | .39902 | .91694 | .41496 | .90984 | 29 |
| 32 | .35075 | .93647 | .36704 | .93020 | .38322 | .92366 | .39928 | .91683 | .41522 | .90972 | 28 |
| 33 | .35102 | .93637 | .36731 | .93010 | .38349 | .92355 | .39955 | .91671 | .41549 | .90960 | 27 |
| 34 | .35130 | .93626 | .36758 | .92999 | .38376 | .92343 | .39982 | .91660 | .41575 | .90948 | 26 |
| 35 | .35157 | .93616 | .36785 | .92988 | .38403 | .92332 | .40008 | .91648 | .41602 | .90936 | 25 |
| 36 | .35184 | .93606 | .36812 | .92978 | .38430 | .92321 | .40035 | .91636 | .41628 | .90924 | 24 |
| 37 | .35211 | .93596 | .36839 | .92967 | .38456 | .92310 | .40062 | .91625 | .41655 | .90911 | 23 |
| 38 | .35239 | .93585 | .36867 | .92956 | .38483 | .92299 | .40088 | .91613 | .41681 | .90899 | 22 |
| 39 | .35266 | .93575 | .36894 | .92945 | .38510 | .92287 | .40115 | .91601 | .41707 | .90887 | 21 |
| 40 | .35293 | .93565 | .36921 | .92935 | .38537 | .92276 | .40141 | .91590 | .41734 | .90875 | 20 |
| 41 | .35320 | .93555 | .36948 | .92924 | .38564 | .92265 | .40168 | .91578 | .41760 | .90863 | 19 |
| 42 | .35347 | .93544 | .36975 | .92913 | .38591 | .92254 | .40195 | .91566 | .41787 | .90851 | 18 |
| 43 | .35375 | .93534 | .37002 | .92902 | .38617 | .92243 | .40221 | .91555 | .41813 | .90839 | 17 |
| 44 | .35402 | .93524 | .37029 | .92892 | .38644 | .92231 | .40248 | .91543 | .41840 | .90826 | 16 |
| 45 | .35429 | .93514 | .37056 | .92881 | .38671 | .92220 | .40275 | .91531 | .41866 | .90814 | 15 |
| 46 | .35456 | .93503 | .37083 | .92870 | .38698 | .92209 | .40301 | .91519 | .41892 | .90802 | 14 |
| 47 | .35484 | .93493 | .37110 | .92859 | .38725 | .92198 | .40328 | .91508 | .41919 | .90790 | 13 |
| 48 | .35511 | .93483 | .37137 | .92849 | .38752 | .92186 | .40355 | .91496 | .41945 | .90778 | 12 |
| 49 | .35538 | .93472 | .37164 | .92838 | .38778 | .92175 | .40381 | .91484 | .41972 | .90766 | 11 |
| 50 | .35565 | .93462 | .37191 | .92827 | .38805 | .92164 | .40408 | .91472 | .41998 | .90753 | 10 |
| 51 | .35592 | .93452 | .37218 | .92816 | .38832 | .92152 | .40434 | .91461 | .42024 | .90741 | 9 |
| 52 | .35619 | .93441 | .37245 | .92805 | .38859 | .92141 | .40461 | .91449 | .42051 | .90729 | 8 |
| 53 | .35647 | .93431 | .37272 | .92794 | .38886 | .92130 | .40488 | .91437 | .42077 | .90717 | 7 |
| 54 | .35674 | .93420 | .37299 | .92784 | .38912 | .92119 | .40514 | .91425 | .42104 | .90704 | 6 |
| 55 | .35701 | .93410 | .37326 | .92773 | .38939 | .92107 | .40541 | .91414 | .42130 | .90692 | 5 |
| 56 | .35728 | .93400 | .37353 | .92762 | .38966 | .92096 | .40567 | .91402 | .42156 | .90680 | 4 |
| 57 | .35755 | .93389 | .37380 | .92751 | .38993 | .92085 | .40594 | .91390 | .42183 | .90668 | 3 |
| 58 | .35782 | .93379 | .37407 | .92740 | .39020 | .92073 | .40621 | .91378 | .42209 | .90655 | 2 |
| 59 | .35810 | .93368 | .37434 | .92729 | .39046 | .92062 | .40647 | .91366 | .42235 | .90643 | 1 |
| 60 | .35837 | .93358 | .37461 | .92718 | .39073 | .92050 | .40674 | .91355 | .42262 | .90631 | 0 |
| M. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine | Cosin. | Sine. | M. |
| | 69° | | 68° | | 67° | | 66° | | 65° | | |

| M. | 25° Sine. | 25° Cosin. | 26° Sine. | 26° Cosin. | 27° Sine. | 27° Cosin | 28° Sine. | 28° Cosin | 29° Sine. | 29° Cosin. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .42262 | .90631 | .43837 | .89879 | .45399 | .89101 | .46947 | .88295 | .48481 | .87462 | 60 |
| 1 | .42288 | .90618 | .43863 | .89867 | .45425 | .89087 | .46973 | .88281 | .48506 | .87448 | 59 |
| 2 | .42315 | .90606 | .43889 | .89854 | .45451 | .89074 | .46999 | .88267 | .48532 | .87434 | 58 |
| 3 | .42341 | .90594 | .43916 | .89841 | .45477 | .89061 | .47024 | .88254 | .48557 | .87420 | 57 |
| 4 | .42367 | .90582 | .43942 | .89828 | .45503 | .89048 | .47050 | .88240 | .48583 | .87406 | 56 |
| 5 | .42394 | .90569 | .43968 | .89816 | .45529 | .89035 | .47076 | .88226 | .48608 | .87391 | 55 |
| 6 | .42420 | .90557 | .43994 | .89803 | .45554 | .89021 | .47101 | .88213 | .48634 | .87377 | 54 |
| 7 | .42446 | .90545 | .44020 | .89790 | .45580 | .89008 | .47127 | .88199 | .48659 | .87363 | 53 |
| 8 | .42473 | .90532 | .44046 | .89777 | .45606 | .88995 | .47153 | .88185 | .48684 | .87349 | 52 |
| 9 | .42499 | .90520 | .44072 | .89764 | .45632 | .88981 | .47178 | .88172 | .48710 | .87335 | 51 |
| 10 | .42525 | .90507 | .44098 | .89752 | .45658 | .88968 | .47204 | .88158 | .48735 | .87321 | 50 |
| 11 | .42552 | .90195 | .44124 | .89739 | .45684 | .88955 | .47229 | .88144 | .48761 | .87306 | 49 |
| 12 | .42578 | .90483 | .44151 | .89726 | .45710 | .88942 | .47255 | .88130 | .48786 | .87292 | 48 |
| 13 | .43604 | .90470 | .44177 | .89713 | .45736 | .88928 | .47281 | .88117 | .48811 | .87278 | 47 |
| 14 | .42631 | .90458 | .44203 | .89700 | .45762 | .88915 | .47306 | .88103 | .48837 | .87264 | 46 |
| 15 | .42657 | .90446 | .44229 | .89687 | .45787 | .88902 | .47332 | .88089 | .48862 | .87250 | 45 |
| 16 | .42683 | .90433 | .44255 | .89674 | .45813 | .88888 | .47358 | .88075 | .48888 | .87235 | 44 |
| 17 | .42709 | .90421 | .44281 | .89662 | .45839 | .88875 | .47383 | .88062 | .48913 | .87221 | 43 |
| 18 | .42736 | .90408 | .44307 | .89649 | .45865 | .88862 | .47409 | .88048 | .48938 | .87207 | 42 |
| 19 | .42762 | .90396 | .44333 | .89636 | .45891 | .88848 | .47434 | .88034 | .48964 | .87193 | 41 |
| 20 | .42788 | .90383 | .44359 | .89623 | .45917 | .88835 | .47460 | .88020 | .48989 | .87178 | 40 |
| 21 | .42815 | .90371 | .44385 | .89610 | .45942 | .88822 | .47486 | .88006 | .49014 | .87164 | 39 |
| 22 | .42841 | .90358 | .44411 | .89597 | .45968 | .88808 | .47511 | .87993 | .49040 | .87150 | 38 |
| 23 | .42867 | .90346 | .44437 | .89584 | .45994 | .88795 | .47537 | .87979 | .49065 | .87136 | 37 |
| 24 | .42894 | .90334 | .44464 | .89571 | .46020 | .88782 | .47562 | .87965 | .49090 | .87121 | 36 |
| 25 | .42920 | .90321 | .44490 | .89558 | .46046 | .88768 | .47588 | .87951 | .49116 | .87107 | 35 |
| 26 | .42946 | .90309 | .44516 | .89545 | .46072 | .88755 | .47614 | .87937 | .49141 | .87093 | 34 |
| 27 | .42972 | .90296 | .44542 | .89532 | .46097 | .88741 | .47639 | .87923 | .49166 | .87079 | 33 |
| 28 | .42999 | .90284 | .44568 | .89519 | .46123 | .88728 | .47665 | .87909 | .49192 | .87064 | 32 |
| 29 | .43025 | .90271 | .44594 | .89506 | .46149 | .88715 | .47690 | .87896 | .49217 | .87050 | 31 |
| 30 | .43051 | .90259 | .44620 | .89493 | .46175 | .88701 | .47716 | .87882 | .49242 | .87036 | 30 |
| 31 | .43077 | .90246 | .44646 | .89480 | .46201 | .88688 | .47741 | .87868 | .49268 | .87021 | 29 |
| 32 | .43104 | .90233 | .44672 | .89467 | .46226 | .88674 | .47767 | .87854 | .49293 | .87007 | 28 |
| 33 | .43130 | .90221 | .44698 | .89454 | .46252 | .88661 | .47793 | .87840 | .49318 | .86993 | 27 |
| 34 | .43156 | .90208 | .44724 | .89441 | .46278 | .88647 | .47818 | .87826 | .49344 | .86978 | 26 |
| 35 | .43182 | .90196 | .44750 | .89428 | .46304 | .88634 | .47844 | .87812 | .49369 | .86964 | 25 |
| 36 | .43209 | .90183 | .44776 | .89415 | .46330 | .88620 | .47869 | .87798 | .49394 | .86949 | 24 |
| 37 | .43235 | .90171 | .44802 | .89402 | .46355 | .88607 | .47895 | .87784 | .49419 | .86935 | 23 |
| 38 | .43261 | .90158 | .44828 | .89389 | .46381 | .88593 | .47920 | .87770 | .49445 | .86921 | 22 |
| 39 | .43287 | .90146 | .44854 | .89376 | .46407 | .88580 | .47946 | .87756 | .49470 | .86906 | 21 |
| 40 | .43313 | .90133 | .44880 | .89363 | .46433 | .88566 | .47971 | .87743 | .49495 | .86892 | 20 |
| 41 | .43340 | .90120 | .44906 | .89350 | .46458 | .88553 | .47997 | .87729 | .49521 | .86878 | 19 |
| 42 | .43366 | .90108 | .44932 | .89337 | .46484 | .88539 | .48022 | .87715 | .49546 | .86863 | 18 |
| 43 | .43392 | .90095 | .44958 | .89324 | .46510 | .88526 | .48048 | .87701 | .49571 | .86849 | 17 |
| 44 | .43418 | .90082 | .44984 | .89311 | .46536 | .88512 | .48073 | .87687 | .49596 | .86834 | 16 |
| 45 | .43445 | .90070 | .45010 | .89298 | .46561 | .88499 | .48099 | .87673 | .49622 | .86820 | 15 |
| 46 | .43471 | .90057 | .45036 | .89285 | .46587 | .88485 | .48124 | .87659 | .49647 | .86805 | 14 |
| 47 | .43497 | .90045 | .45062 | .89272 | .46613 | .88472 | .48150 | .87645 | .49672 | .86791 | 13 |
| 48 | .43523 | .90032 | .45088 | .89259 | .46639 | .88458 | .48175 | .87631 | .49697 | .86777 | 12 |
| 49 | .43549 | .90019 | .45114 | .89245 | .46664 | .88445 | .48201 | .87617 | .49723 | .86762 | 11 |
| 50 | .43575 | .90007 | .45140 | .89232 | .46690 | .88431 | .48226 | .87603 | .49748 | .86748 | 10 |
| 51 | .43602 | .89994 | .45166 | .89219 | .46716 | .88417 | .48252 | .87589 | .49773 | .86733 | 9 |
| 52 | .43628 | .89981 | .45192 | .89206 | .46742 | .88404 | .48277 | .87575 | .49798 | .86719 | 8 |
| 53 | .43654 | .89968 | .45218 | .89193 | .46767 | .88390 | .48303 | .87561 | .49824 | .86704 | 7 |
| 54 | .43680 | .89956 | .45243 | .89180 | .46793 | .88377 | .48328 | .87546 | .49849 | .86690 | 6 |
| 55 | .43706 | .89943 | .45269 | .89167 | .46819 | .88363 | .48354 | .87532 | .49874 | .86675 | 5 |
| 56 | .43733 | .89930 | .45295 | .89153 | .46844 | .88349 | .48379 | .87518 | .49899 | .86661 | 4 |
| 57 | .43759 | .89918 | .45321 | .89140 | .46870 | .88336 | .48405 | .87504 | .49924 | .86646 | 3 |
| 58 | .43785 | .89905 | .45347 | .89127 | .46896 | .88322 | .48430 | .87490 | .49950 | .86632 | 2 |
| 59 | .43811 | .89892 | .45373 | .89114 | .46921 | .88308 | .48456 | .87476 | .49975 | .86617 | 1 |
| 60 | .43837 | .89879 | .45399 | .89101 | .46947 | .88295 | .48481 | .87462 | .50000 | .86603 | 0 |
| M. | 64° Cosin. | 64° Sine. | 63° Cosin. | 63° Sine. | 62° Cosin. | 62° Sine. | 61° Cosin. | 61° Sine. | 60° Cosin. | 60° Sine. | M. |

| M. | 30° Sine. | 30° Cosin. | 31° Sine. | 31° Cosin. | 32° Sine. | 32° Cosin. | 33° Sine. | 33° Cosin. | 34° Sine. | 34° Cosin. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .50000 | .86603 | .51504 | .85717 | .52992 | .84805 | .54464 | .83867 | .55919 | .82904 | 60 |
| 1 | .50025 | .86588 | .51529 | .85702 | .53017 | .84789 | .54488 | .83851 | .55943 | .82887 | 59 |
| 2 | .50050 | .86573 | .51554 | .85687 | .53041 | .84774 | .54513 | .83835 | .55968 | .82871 | 58 |
| 3 | .50076 | .86559 | .51579 | .85672 | .53066 | .84759 | .54537 | .83819 | .55992 | .82855 | 57 |
| 4 | .50101 | .86544 | .51604 | .85657 | .53091 | .84743 | .54561 | .83804 | .56016 | .82839 | 56 |
| 5 | .50126 | .86530 | .51628 | .85642 | .53115 | .84728 | .54586 | .83788 | .56040 | .82822 | 55 |
| 6 | .50151 | .86515 | .51653 | .85627 | .53140 | .84712 | .54610 | .83772 | .56064 | .82806 | 54 |
| 7 | .50176 | .86501 | .51678 | .85612 | .53164 | .84697 | .54635 | .83756 | .56088 | .82790 | 53 |
| 8 | .50201 | .86486 | .51703 | .85597 | .53189 | .84681 | .54659 | .83740 | .56112 | .82773 | 52 |
| 9 | .50227 | .86471 | .51728 | .85582 | .53214 | .84666 | .54683 | .83724 | .56136 | .82757 | 51 |
| 10 | .50252 | .86457 | .51753 | .85567 | .53238 | .84650 | .54708 | .83708 | .56160 | .82741 | 50 |
| 11 | .50277 | .86442 | .51778 | .85551 | .53263 | .84635 | .54732 | .83692 | .56184 | .82724 | 49 |
| 12 | .50302 | .86427 | .51803 | .85536 | .53288 | .84619 | .54756 | .83676 | .56208 | .82708 | 48 |
| 13 | .50327 | .86413 | .51828 | .85521 | .53312 | .84604 | .54781 | .83660 | .56232 | .82692 | 47 |
| 14 | .50352 | .86398 | .51852 | .85506 | .53337 | .84588 | .54805 | .83645 | .56256 | .82675 | 46 |
| 15 | .50377 | .86384 | .51877 | .85491 | .53361 | .84573 | .54829 | .83629 | .56280 | .82659 | 45 |
| 16 | .50403 | .86369 | .51902 | .85476 | .53386 | .84557 | .54854 | .83613 | .56305 | .82643 | 44 |
| 17 | .50428 | .86354 | .51927 | .85461 | .53411 | .84542 | .54878 | .83597 | .56329 | .82626 | 43 |
| 18 | .50453 | .86340 | .51952 | .85446 | .53435 | .84526 | .54902 | .83581 | .56353 | .82610 | 42 |
| 19 | .50478 | .86325 | .51977 | .85431 | .53460 | .84511 | .54927 | .83565 | .56377 | .82593 | 41 |
| 20 | .50503 | .86310 | .52002 | .85416 | .53484 | .84496 | .54951 | .83549 | .56401 | .82577 | 40 |
| 21 | .50528 | .86295 | .52026 | .85401 | .53509 | .84480 | .54975 | .83533 | .56425 | .82561 | 39 |
| 22 | .50553 | .86281 | .52051 | .85385 | .53534 | .84464 | .54999 | .83517 | .56449 | .82544 | 38 |
| 23 | .50578 | .86266 | .52076 | .85370 | .53558 | .84448 | .55024 | .83501 | .56473 | .82528 | 37 |
| 24 | .50603 | .86251 | .52101 | .85355 | .53583 | .84433 | .55048 | .83485 | .56497 | .82511 | 36 |
| 25 | .50628 | .86237 | .52126 | .85340 | .53607 | .84417 | .55072 | .83469 | .56521 | .82495 | 35 |
| 26 | .50654 | .86222 | .52151 | .85325 | .53632 | .84402 | .55097 | .83453 | .56545 | .82478 | 34 |
| 27 | .50679 | .86207 | .52175 | .85310 | .53656 | .84386 | .55121 | .83437 | .56569 | .82462 | 33 |
| 28 | .50704 | .86192 | .52200 | .85294 | .53681 | .84370 | .55145 | .83421 | .56593 | .82446 | 32 |
| 29 | .50729 | .86178 | .52225 | .85279 | .53705 | .84355 | .55169 | .83405 | .56617 | .82429 | 31 |
| 30 | .50754 | .86163 | .52250 | .85264 | .53730 | .84339 | .55194 | .83389 | .56641 | .82413 | 30 |
| 31 | .50779 | .86148 | .52275 | .85249 | .53754 | .84324 | .55218 | .83373 | .56665 | .82396 | 29 |
| 32 | .50804 | .86133 | .52299 | .85234 | .53779 | .84308 | .55242 | .83356 | .56689 | .82380 | 28 |
| 33 | .50829 | .86119 | .52324 | .85218 | .53804 | .84292 | .55266 | .83340 | .56713 | .82363 | 27 |
| 34 | .50854 | .86104 | .52349 | .85203 | .53828 | .84277 | .55291 | .83324 | .56736 | .82347 | 26 |
| 35 | .50879 | .86089 | .52374 | .85188 | .53853 | .84261 | .55315 | .83308 | .56760 | .82330 | 25 |
| 36 | .50904 | .86074 | .52399 | .85173 | .53877 | .84245 | .55339 | .83292 | .56784 | .82314 | 24 |
| 37 | .50929 | .86059 | .52423 | .85157 | .53902 | .84230 | .55363 | .83276 | .56808 | .82297 | 23 |
| 38 | .50954 | .86045 | .52448 | .85142 | .53926 | .84214 | .55388 | .83260 | .56832 | .82281 | 22 |
| 39 | .50979 | .86030 | .52473 | .85127 | .53951 | .84198 | .55412 | .83244 | .56856 | .82264 | 21 |
| 40 | .51004 | .86015 | .52498 | .85112 | .53975 | .84182 | .55436 | .83228 | .56880 | .82248 | 20 |
| 41 | .51029 | .86000 | .52522 | .85096 | .54000 | .84167 | .55460 | .83212 | .56904 | .82231 | 19 |
| 42 | .51054 | .85985 | .52547 | .85081 | .54024 | .84151 | .55484 | .83195 | .56928 | .82214 | 18 |
| 43 | .51079 | .85970 | .52572 | .85066 | .54049 | .84135 | .55509 | .83179 | .56952 | .82198 | 17 |
| 44 | .51104 | .85956 | .52597 | .85051 | .54073 | .84120 | .55533 | .83163 | .56976 | .82181 | 16 |
| 45 | .51129 | .85941 | .52621 | .85035 | .54097 | .84104 | .55557 | .83147 | .57000 | .82165 | 15 |
| 46 | .51154 | .85926 | .52646 | .85020 | .54122 | .84088 | .55581 | .83131 | .57024 | .82148 | 14 |
| 47 | .51179 | .85911 | .52671 | .85005 | .54146 | .84072 | .55605 | .83115 | .57047 | .82132 | 13 |
| 48 | .51204 | .85896 | .52696 | .84989 | .54171 | .84057 | .55630 | .83098 | .57071 | .82115 | 12 |
| 49 | .51229 | .85881 | .52720 | .84974 | .54195 | .84041 | .55654 | .83082 | .57095 | .82098 | 11 |
| 50 | .51254 | .85866 | .52745 | .84959 | .54220 | .84025 | .55678 | .83066 | .57119 | .82082 | 10 |
| 51 | .51279 | .85851 | .52770 | .84943 | .54244 | .84009 | .55702 | .83050 | .57143 | .82065 | 9 |
| 52 | .51304 | .85836 | .52794 | .84928 | .54269 | .83994 | .55726 | .83034 | .57167 | .82048 | 8 |
| 53 | .51329 | .85821 | .52819 | .84913 | .54293 | .83978 | .55750 | .83017 | .57191 | .82032 | 7 |
| 54 | .51351 | .85806 | .52844 | .84897 | .54317 | .83962 | .55775 | .83001 | .57215 | .82015 | 6 |
| 55 | .51379 | .85792 | .52869 | .84882 | .54342 | .83946 | .55799 | .82985 | .57238 | .81999 | 5 |
| 56 | .51404 | .85777 | .52893 | .84866 | .54366 | .83930 | .55823 | .82969 | .57262 | .81982 | 4 |
| 57 | .51429 | .85762 | .52918 | .84851 | .54391 | .83915 | .55847 | .82953 | .57286 | .81965 | 3 |
| 58 | .51451 | .85747 | .52943 | .84836 | .54415 | .83899 | .55871 | .82936 | .57310 | .81949 | 2 |
| 59 | .51479 | .85732 | .52967 | .84820 | .54440 | .83883 | .55895 | .82920 | .57334 | .81932 | 1 |
| 60 | .51504 | .85717 | .52992 | .84805 | .54464 | .83867 | .55919 | .82904 | .57358 | .81915 | 0 |
| M. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | Cosin | Sine. | M. |
| | 59° | | 58° | | 57° | | 56° | | 55° | | |

| M. | 35° Sine. | 35° Cosin. | 36° Sine. | 36° Cosin | 37° Sine. | 37° Cosin. | 38° Sine. | 38° Co in. | 39° Sine. | 39° Cosin. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .57358 | .81915 | .58779 | .80902 | .60182 | .79864 | .61566 | .78801 | .62932 | .77715 | 60 |
| 1 | .57381 | .81899 | .58802 | .80885 | .60205 | .79846 | .61589 | .78783 | .62955 | .77696 | 59 |
| 2 | .57405 | .81882 | .58826 | .80867 | .60228 | .79829 | .61612 | .78765 | .62977 | .77678 | 58 |
| 3 | .57429 | .81865 | .58849 | .80850 | .60251 | .79811 | .61635 | .78747 | .63000 | .77660 | 57 |
| 4 | .57453 | .81848 | .58873 | .80833 | .60274 | .79793 | .61658 | .78729 | .63022 | .77641 | 56 |
| 5 | .57477 | .81832 | .58896 | .80816 | .60298 | .79776 | .61681 | .78711 | .63045 | .77623 | 55 |
| 6 | .57501 | .81815 | .58920 | .80799 | .60321 | .79758 | .61704 | .78694 | .63068 | .77605 | 54 |
| 7 | .57524 | .81798 | .58943 | .80782 | .60344 | .79741 | .61726 | .78676 | .63090 | .77586 | 53 |
| 8 | .57548 | .81782 | .58967 | .80765 | .60367 | .79723 | .61749 | .78658 | .63113 | .77568 | 52 |
| 9 | .57572 | .81765 | .58990 | .80748 | .60390 | .79706 | .61772 | .78640 | .63135 | .77550 | 51 |
| 10 | .57596 | .81748 | .59014 | .80730 | .60414 | .79688 | .61795 | .78622 | .63158 | .77531 | 50 |
| 11 | .57619 | .81731 | .59037 | .80713 | .60437 | .79671 | .61818 | .78604 | .63180 | .77513 | 49 |
| 12 | .57643 | .81714 | .59061 | .80696 | .60460 | .79653 | .61841 | .78586 | .63203 | .77494 | 48 |
| 13 | .57667 | .81698 | .59084 | .80679 | .60483 | .79635 | .61864 | .78568 | .63225 | .77476 | 47 |
| 14 | .57691 | .81681 | .59108 | .80662 | .60506 | .79618 | .61887 | .78550 | .63248 | .77458 | 46 |
| 15 | .57715 | .81664 | .59131 | .80644 | .60529 | .79600 | .61909 | .78532 | .63271 | .77439 | 45 |
| 16 | .57738 | .81647 | .59154 | .80627 | .60553 | .79583 | .61932 | .78514 | .63293 | .77421 | 44 |
| 17 | .57762 | .81631 | .59178 | .80610 | .60576 | .79565 | .61955 | .78496 | .63316 | .77402 | 43 |
| 18 | .57786 | .81614 | .59201 | .80593 | .60599 | .79547 | .61978 | .78478 | .63338 | .77384 | 42 |
| 19 | .57810 | .81597 | .59225 | .80576 | .60622 | .79530 | .62001 | .78460 | .63361 | .77366 | 41 |
| 20 | .57833 | .81580 | .59248 | .80558 | .60645 | .79512 | .62024 | .78442 | .63383 | .77347 | 40 |
| 21 | .57857 | .81563 | .59272 | .80541 | .60668 | .79494 | .62046 | .78424 | .63406 | .77329 | 39 |
| 22 | .57881 | .81546 | .59295 | .80524 | .60691 | .79477 | .62069 | .78405 | .63428 | .77310 | 38 |
| 23 | .57904 | .81530 | .59318 | .80507 | .60714 | .79459 | .62092 | .78387 | .63451 | .77292 | 37 |
| 24 | .57928 | .81513 | .59342 | .80489 | .60738 | .79441 | .62115 | .78369 | .63473 | .77273 | 36 |
| 25 | .57952 | .81496 | .59365 | .80472 | .60761 | .79424 | .62138 | .78351 | .63496 | .77255 | 35 |
| 26 | .57976 | .81479 | .59389 | .80455 | .60784 | .79406 | .62160 | .78333 | .63518 | .77236 | 34 |
| 27 | .57999 | .81462 | .59412 | .80438 | .60807 | .79388 | .62183 | .78315 | .63540 | .77218 | 33 |
| 28 | .58023 | .81445 | .59436 | .80420 | .60830 | .79371 | .62206 | .78297 | .63563 | .77199 | 32 |
| 29 | .58047 | .81428 | .59459 | .80403 | .60853 | .79353 | .62229 | .78279 | .63585 | .77181 | 31 |
| 30 | .58070 | .81412 | .59482 | .80386 | .60876 | .79335 | .62251 | .78261 | .63608 | .77162 | 30 |
| 31 | .58094 | .81395 | .59506 | .80368 | .60899 | .79318 | .62274 | .78243 | .63630 | .77144 | 29 |
| 32 | .58118 | .81378 | .59529 | .80351 | .60922 | .79300 | .62297 | .78225 | .63653 | .77125 | 28 |
| 33 | .58141 | .81361 | .59552 | .80334 | .60945 | .79282 | .62320 | .78206 | .63675 | .77107 | 27 |
| 34 | .58165 | .81344 | .59576 | .80316 | .60968 | .79264 | .62342 | .78188 | .63698 | .77088 | 26 |
| 35 | .58189 | .81327 | .59599 | .80299 | .60991 | .79247 | .62365 | .78170 | .63720 | .77070 | 25 |
| 36 | .58212 | .81310 | .59622 | .80282 | .61015 | .79229 | .62388 | .78152 | .63742 | .77051 | 24 |
| 37 | .58236 | .81293 | .59646 | .80264 | .61038 | .79211 | .62411 | .78134 | .63765 | .77033 | 23 |
| 38 | .58260 | .81276 | .59669 | .80247 | .61061 | .79193 | .62433 | .78116 | .63787 | .77014 | 22 |
| 39 | .58283 | .81259 | .59693 | .80230 | .61084 | .79176 | .62456 | .78098 | .63810 | .76996 | 21 |
| 40 | .58307 | .81242 | .59716 | .80212 | .61107 | .79158 | .62479 | .78079 | .63832 | .76977 | 20 |
| 41 | .58330 | .81225 | .59739 | .80195 | .61130 | .79140 | .62502 | .78061 | .63854 | .76959 | 19 |
| 42 | .58354 | .81208 | .59763 | .80178 | .61153 | .79122 | .62524 | .78043 | .63877 | .76940 | 18 |
| 43 | .58378 | .81191 | .59786 | .80160 | .61176 | .79105 | .62547 | .78025 | .63899 | .76921 | 17 |
| 44 | .58401 | .81174 | .59809 | .80143 | .61199 | .79087 | .62570 | .78007 | .63922 | .76903 | 16 |
| 45 | .58425 | .81157 | .59832 | .80125 | .61222 | .79069 | .62592 | .77988 | .63944 | .76884 | 15 |
| 46 | .58449 | .81140 | .59856 | .80108 | .61245 | .79051 | .62615 | .77970 | .63966 | .76866 | 14 |
| 47 | .58472 | .81123 | .59879 | .80091 | .61268 | .79033 | .62638 | .77952 | .63989 | .76847 | 13 |
| 48 | .58496 | .81106 | .59902 | .80073 | .61291 | .79016 | .62660 | .77934 | .64011 | .76828 | 12 |
| 49 | .58519 | .81089 | .59926 | .80056 | .61314 | .78998 | .62683 | .77916 | .64033 | .76810 | 11 |
| 50 | .58543 | .81072 | .59949 | .80038 | .61337 | .78980 | .62706 | .77897 | .64056 | .76791 | 10 |
| 51 | .58567 | .81055 | .59972 | .80021 | .61360 | .78962 | .62728 | .77879 | .64078 | .76772 | 9 |
| 52 | .58590 | .81038 | .59995 | .80003 | .61383 | .78944 | .62751 | .77861 | .64100 | .76754 | 8 |
| 53 | .58614 | .81021 | .60019 | .79986 | .61406 | .78926 | .62774 | .77843 | .64123 | .76735 | 7 |
| 54 | .58637 | .81004 | .60042 | .79968 | .61429 | .78908 | .62796 | .77824 | .64145 | .76717 | 6 |
| 55 | .58661 | .80987 | .60065 | .79951 | .61451 | .78891 | .62819 | .77806 | .64167 | .76698 | 5 |
| 56 | .58684 | .80970 | .60089 | .79934 | .61474 | .78873 | .62842 | .77788 | .64190 | .76679 | 4 |
| 57 | .58708 | .80953 | .60112 | .79916 | .61497 | .78855 | .62864 | .77769 | .64212 | .76661 | 3 |
| 58 | .58731 | .80936 | .60135 | .79899 | .61520 | .78837 | .62887 | .77751 | .64234 | .76642 | 2 |
| 59 | .58755 | .80919 | .60158 | .79881 | .61543 | .78819 | .62909 | .77733 | .64256 | .76623 | 1 |
| 60 | .58779 | .80902 | .60182 | .79864 | .61566 | .78801 | .62932 | .77715 | .64279 | .76604 | 0 |
| M. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine | Cosin. | Sine. | M. |
| | 54° | | 53° | | 52° | | 51° | | 50° | | |

| M. | 40° Sine. | 40° Cosin. | 41° Sine. | 41° Cosin | 42° Sine. | 42° Cosin. | 43° Sine. | 43° Cosin. | 44° Sine. | 44° Cosin. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .64279 | .76604 | .65606 | .75471 | .66913 | .74314 | .68200 | .73135 | .69466 | .71934 | 60 |
| 1 | .64301 | .76586 | .65628 | .75452 | .66935 | .74295 | .68221 | .73115 | .69487 | .71914 | 59 |
| 2 | .64323 | .76567 | .65650 | .75433 | .66956 | .74276 | .68242 | .73096 | .6958 8 | .71894 | 58 |
| 3 | .64346 | .76548 | .65672 | .75414 | .66978 | .74256 | .68264 | .73076 | .69529 | .71873 | 57 |
| 4 | .64368 | .76530 | .65694 | .75395 | .66999 | .74237 | .68285 | .73056 | .69549 | .71853 | 56 |
| 5 | .64390 | .76511 | .65716 | .75375 | .67021 | .74217 | .68306 | .73036 | .69570 | .71833 | 55 |
| 6 | .64412 | .76492 | .65738 | .75356 | .67043 | .74198 | .68327 | .73016 | .69591 | .71813 | 54 |
| 7 | .64435 | .76473 | .65759 | .75337 | .67064 | .74178 | .68349 | .72996 | .69612 | .71792 | 53 |
| 8 | .64457 | .76455 | .65781 | .75318 | .67086 | .74159 | .68370 | .72976 | .69633 | .71772 | 52 |
| 9 | .64479 | .76436 | .65803 | .75299 | .67107 | .74139 | .68391 | .72957 | .69654 | .71752 | 51 |
| 10 | .64501 | .76417 | .65825 | .75280 | .67129 | .74120 | .68412 | .72937 | .69675 | .71732 | 50 |
| 11 | .64524 | .76398 | .65847 | .75261 | .67151 | .74100 | .68434 | .72917 | .69696 | .71711 | 49 |
| 12 | .64546 | .76380 | .65869 | .75241 | .67172 | .74080 | .68455 | .72897 | .69717 | .71691 | 48 |
| 13 | .64568 | .76361 | .65891 | .75222 | .67194 | .74061 | .68476 | .72877 | .69737 | .71671 | 47 |
| 14 | .64590 | .76342 | .65913 | .75203 | .67215 | .74041 | .68497 | .72857 | .69758 | .71650 | 46 |
| 15 | .64612 | .76323 | .65935 | .75184 | .67237 | .74022 | .68518 | .72837 | .69779 | .71630 | 45 |
| 16 | .64635 | .76304 | .65956 | .75165 | .67258 | .74002 | .68539 | .72817 | .69800 | .71610 | 44 |
| 17 | .64657 | .76286 | .65978 | .75146 | .67280 | .73983 | .68561 | .72797 | .69821 | .71590 | 43 |
| 18 | .64679 | .76267 | .66000 | .75126 | .67301 | .73963 | .68582 | .72777 | .69842 | .71569 | 42 |
| 19 | .64701 | .76248 | .66022 | .75107 | .67322 | .73944 | .68603 | .72757 | .69862 | .71549 | 41 |
| 20 | .64723 | .76229 | .66044 | .75088 | .67344 | .73924 | .68624 | .72737 | .69883 | .71529 | 40 |
| 21 | .64746 | .76210 | .66066 | .75069 | .67366 | .73904 | .68645 | .72717 | .69904 | .71508 | 39 |
| 22 | .64768 | .76192 | .66088 | .75050 | .67387 | .73885 | .68666 | .72697 | .69925 | .71488 | 38 |
| 23 | .64790 | .67173 | .66109 | .75030 | .67409 | .73865 | .68688 | .72677 | .69946 | .71468 | 37 |
| 24 | .64812 | .76154 | .66131 | .75011 | .67430 | .73846 | .68709 | .72657 | .69966 | .71447 | 36 |
| 25 | .64834 | .76135 | .66153 | .74992 | .67452 | .73826 | .68730 | .72637 | .69987 | .71427 | 35 |
| 26 | .64856 | .76116 | .66175 | .74973 | .67473 | .73806 | .68751 | .72617 | .70008 | .71407 | 34 |
| 27 | .64878 | .76097 | .66197 | .74953 | .67495 | .73787 | .68772 | .72597 | .70029 | .71386 | 33 |
| 28 | .64901 | .76078 | .66218 | .74934 | .67516 | .73767 | .68793 | .72577 | .70049 | .71366 | 32 |
| 29 | .64923 | .76059 | .66240 | .74915 | .67538 | .73747 | .68814 | .72557 | .70070 | .71345 | 31 |
| 30 | .64945 | .76041 | .66262 | .74896 | .67559 | .73728 | .68835 | .72537 | .70091 | .71325 | 30 |
| 31 | .64967 | .76022 | .66284 | .74876 | .67580 | .73708 | .68857 | .72517 | .70112 | .71305 | 29 |
| 32 | .64989 | .76003 | .66306 | .74857 | .67602 | .73688 | .68878 | .72497 | .70132 | .71284 | 28 |
| 33 | .65011 | .75984 | .66327 | .74838 | .67623 | .73669 | .68899 | .72477 | .70153 | .71264 | 27 |
| 34 | .65033 | .75965 | .66349 | .74818 | .67645 | .73649 | .68920 | .72455 | .70174 | .71243 | 26 |
| 35 | .65055 | .75946 | .66371 | .74799 | .67666 | .73629 | .68941 | .72437 | .70195 | .71223 | 25 |
| 36 | .65077 | .75927 | .66393 | .74780 | .67688 | .73610 | .68962 | .72417 | .70215 | .71203 | 24 |
| 37 | .65100 | .75908 | .66414 | .74760 | .67709 | .73590 | .68983 | .72397 | .70236 | .71182 | 23 |
| 38 | .65122 | .75889 | .66436 | .74741 | .67730 | .73570 | .69004 | .72377 | .70257 | .71162 | 22 |
| 39 | .65144 | .75870 | .66458 | .74722 | .67752 | .73551 | .69025 | .72357 | .70277 | .71141 | 21 |
| 40 | .65166 | .75851 | .66480 | .74703 | .67773 | .73531 | .69046 | .72337 | .70298 | .71121 | 20 |
| 41 | .65188 | .75832 | .66501 | .74683 | .67795 | .73511 | .69067 | .72317 | .70319 | .71100 | 19 |
| 42 | .65210 | .75813 | .66523 | .74664 | .67816 | .73491 | .69088 | .72297 | .70339 | .71080 | 18 |
| 43 | .65232 | .75794 | .66545 | .74644 | .67837 | .73472 | .69109 | .72277 | .70360 | .71059 | 17 |
| 44 | .65254 | .75775 | .66566 | .74625 | .67859 | .73452 | .69130 | .72257 | .70381 | .71039 | 16 |
| 45 | .65276 | .75756 | .66588 | .74606 | .67880 | .73432 | .69151 | .72236 | .70401 | .71019 | 15 |
| 46 | .65298 | .75738 | .66610 | .74586 | .67901 | .73413 | .69172 | .72216 | .70422 | .70998 | 14 |
| 47 | .65320 | .75719 | .66632 | .74567 | .67923 | .73393 | .69193 | .72196 | .70443 | .70978 | 13 |
| 48 | .65342 | .75700 | .66653 | .74548 | .67944 | .73373 | .69214 | .72176 | .70463 | .70957 | 12 |
| 49 | .65364 | .75680 | .66675 | .74528 | .67965 | .73353 | .69235 | .72156 | .70484 | .70937 | 11 |
| 50 | .65386 | .75661 | .66697 | .74509 | .67987 | .73333 | .69256 | .72136 | .70505 | .70916 | 10 |
| 51 | .65408 | .75642 | .66718 | .74489 | .68008 | .73314 | .69277 | .72116 | .70525 | .70896 | 9 |
| 52 | .65430 | .75623 | .66740 | .74470 | .68029 | .73294 | .69298 | .72095 | .70546 | .70875 | 8 |
| 53 | .65452 | .75604 | .66762 | .74451 | .68051 | .73274 | .69319 | .72075 | .70567 | .70855 | 7 |
| 54 | .65474 | .75585 | .66783 | .74431 | .68072 | .73254 | .69340 | .72055 | .70587 | .70834 | 6 |
| 55 | .65496 | .75566 | .66805 | .74412 | .68093 | .73234 | .69361 | .72035 | .70608 | .70813 | 5 |
| 56 | .65518 | .75547 | .66827 | .74392 | .68115 | .73215 | .69382 | .72015 | .70628 | .70793 | 4 |
| 57 | .65540 | .75528 | .66848 | .74373 | .68136 | .73195 | .69403 | .71995 | .70649 | .70772 | 3 |
| 58 | .65562 | .75509 | .66870 | .74353 | .68157 | .73175 | .69424 | .71974 | .70670 | .70752 | 2 |
| 59 | .65584 | .75490 | .66891 | .74334 | .68179 | .73155 | .69445 | .71954 | .70690 | .70731 | 1 |
| 60 | .65606 | .75471 | .66913 | .74314 | .68200 | .73135 | .69466 | .71934 | .70711 | .70711 | 0 |
| M. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | Cosin. | Sine. | M. |
| | 49° | | 48° | | 47° | | 46° | | 45° | | |

# TABLE VI.

## NATURAL TANGENTS AND COTANGENTS

| M. | 0° Tang. | 0° Cotang. | 1° Tang. | 1° Cotang. | 2° Tang. | 2° Cotang. | 3° Tang. | 3° Cotang. | M. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | .00000 | Infinite. | .01746 | 57.2900 | .03492 | 28.6363 | .05241 | 19.0811 | 60 |
| 1 | .00029 | 3437.75 | .01775 | 56.8506 | .03521 | 28.3994 | .05270 | 18.9755 | 59 |
| 2 | .00058 | 1718.87 | .01804 | 55.4415 | .03550 | 28.1664 | .05299 | 18.8711 | 58 |
| 3 | .00087 | 1145.92 | .01833 | 54.5613 | .03597 | 27.9372 | .05328 | 18.7678 | 57 |
| 4 | .00116 | 859.436 | .01862 | 53.7086 | .03609 | 27.7117 | .05357 | 18.6656 | 56 |
| 5 | .00145 | 687.549 | .01891 | 52.8821 | .03638 | 27.4899 | .05387 | 18.5645 | 55 |
| 6 | .00175 | 572.957 | .01920 | 52.0807 | .03667 | 27.2715 | .05416 | 18.4645 | 54 |
| 7 | .00204 | 491.106 | .01949 | 51.3032 | .03696 | 27.0566 | .05445 | 18.3655 | 53 |
| 8 | .00233 | 429.718 | .01978 | 50.5485 | .03725 | 26.8450 | .05474 | 18.2677 | 52 |
| 9 | .00262 | 381.971 | .02007 | 49.8157 | .03754 | 26.6367 | .05503 | 18.1708 | 51 |
| 10 | .00291 | 343.774 | .02036 | 49.1039 | .03783 | 26.4316 | .05533 | 18.0750 | 50 |
| 11 | .00320 | 312.521 | .02066 | 48.4121 | .03812 | 26.2296 | .05562 | 17.9802 | 49 |
| 12 | .00349 | 286.478 | .02095 | 47.7395 | .03842 | 26.0307 | .05591 | 17.8863 | 48 |
| 13 | .00378 | 264.441 | .02124 | 47.0853 | .03871 | 25.8348 | .05620 | 17.7934 | 47 |
| 14 | .00407 | 245.552 | .02153 | 46.4489 | .03900 | 25.6418 | .05649 | 17.7015 | 46 |
| 15 | .00436 | 229.182 | .02182 | 45.8294 | .03929 | 25.4517 | .05678 | 17.6106 | 45 |
| 16 | .00465 | 214.858 | .02211 | 45.2261 | .03958 | 25.2644 | .05708 | 17.5205 | 44 |
| 17 | .00495 | 202.219 | .02240 | 44.6386 | .03987 | 25.0798 | .05737 | 17.4314 | 43 |
| 18 | .00524 | 190.984 | .02269 | 44.0661 | .04016 | 24.8978 | .05766 | 17.3432 | 42 |
| 19 | .00553 | 180.932 | .02298 | 43.5081 | .04046 | 24.7185 | .05795 | 17.2558 | 41 |
| 20 | .00582 | 171.885 | .02328 | 42.9641 | .04075 | 24.5418 | .05824 | 17.1693 | 40 |
| 21 | .00611 | 163.700 | .02357 | 42.4335 | .04104 | 24.3675 | .05854 | 17.0837 | 39 |
| 22 | .00640 | 156.259 | .02386 | 41.9158 | .04133 | 24.1957 | .05883 | 16.9990 | 38 |
| 23 | .00669 | 149.465 | .02415 | 41.4106 | .04162 | 24.0263 | .05912 | 16.9150 | 37 |
| 24 | .00698 | 143.237 | .02444 | 40.9174 | .04191 | 23.8593 | .05941 | 16.8319 | 36 |
| 25 | .00727 | 137.507 | .02473 | 40.4358 | .04220 | 23.6945 | .05970 | 16.7496 | 35 |
| 26 | .00756 | 132.219 | .02502 | 39.9655 | .04250 | 23.5321 | .05999 | 16.6681 | 34 |
| 27 | .00785 | 127.321 | .02531 | 39.5059 | .04279 | 23.3718 | .06029 | 16.5874 | 33 |
| 28 | .00815 | 122.774 | .02560 | 39.0568 | .04308 | 23.2137 | .06058 | 16.5075 | 32 |
| 29 | .00844 | 118.540 | .02589 | 38.6177 | .04337 | 23.0577 | .06087 | 16.4283 | 31 |
| 30 | .00873 | 114.589 | .02619 | 38.1885 | .04366 | 22.9038 | .06116 | 16.3499 | 30 |
| 31 | .00902 | 110.892 | .02648 | 37.7686 | .04395 | 22.7519 | .06145 | 16.2722 | 29 |
| 32 | .00931 | 107.426 | .02677 | 37.3579 | .04424 | 22.6020 | .06175 | 16.1952 | 28 |
| 33 | .00960 | 104.171 | .02706 | 36.9560 | .04454 | 22.4541 | .06204 | 16.1190 | 27 |
| 34 | .00989 | 101.107 | .02735 | 36.5627 | .04483 | 22.3081 | .06233 | 16.0435 | 26 |
| 35 | .01018 | 98.2179 | .02764 | 36.1776 | .04512 | 22.1640 | .06262 | 15.9687 | 25 |
| 36 | .01047 | 95.4895 | .02793 | 35.8006 | .04541 | 22.0217 | .06291 | 15.8945 | 24 |
| 37 | .01076 | 92.9085 | .02822 | 35.4313 | .04570 | 21.8813 | .06321 | 15.8211 | 23 |
| 38 | .01105 | 90.4633 | .02851 | 35.0695 | .04599 | 21.7426 | .06350 | 15.7483 | 22 |
| 39 | .01135 | 88.1436 | .02881 | 34.7151 | .04628 | 21.6056 | .06379 | 15.6762 | 21 |
| 40 | .01164 | 85.9398 | .02910 | 34.3678 | .04658 | 21.4704 | .06408 | 15.6048 | 20 |
| 41 | .01193 | 83.8435 | .02939 | 34.0273 | .04687 | 21.3369 | .06437 | 15.5340 | 19 |
| 42 | .01222 | 81.8470 | .02968 | 33.6935 | .04716 | 21.2049 | .06467 | 15.4638 | 18 |
| 43 | .01251 | 79.9434 | .02997 | 33.3662 | .04745 | 21.0747 | .06496 | 15.3943 | 17 |
| 44 | .01280 | 78.1263 | .03026 | 33.0452 | .04774 | 20.9460 | .06525 | 15.3254 | 16 |
| 45 | .01309 | 76.3900 | .03055 | 32.7303 | .04803 | 20.8188 | .06554 | 15.2571 | 15 |
| 46 | .01338 | 74.7292 | .03084 | 32.4213 | .04833 | 20.6932 | .06584 | 15.1893 | 14 |
| 47 | .01367 | 73.1390 | .03114 | 32.1181 | .04862 | 20.5691 | .06613 | 15.1222 | 13 |
| 48 | .01396 | 71.6151 | .03143 | 31.8205 | .04891 | 20.4465 | .06642 | 15.0557 | 12 |
| 49 | .01425 | 70.1533 | .03172 | 31.5284 | .04920 | 20.3253 | .06671 | 14.9898 | 11 |
| 50 | .01455 | 68.7501 | .03201 | 31.2416 | .04949 | 20.2056 | .06700 | 14.9244 | 10 |
| 51 | .01484 | 67.4019 | .03230 | 30.9599 | .04978 | 20.0872 | .06730 | 14.8596 | 9 |
| 52 | .01513 | 66.1055 | .03259 | 30.6833 | .05007 | 19.9702 | .06759 | 14.7954 | 8 |
| 53 | .01542 | 64.8580 | .03288 | 30.4116 | .05037 | 19.8546 | .06788 | 14.7317 | 7 |
| 54 | .01571 | 63.6567 | .03317 | 30.1446 | .05066 | 19.7403 | .06817 | 14.6685 | 6 |
| 55 | .01600 | 62.4992 | .03346 | 29.8823 | .05095 | 19.6273 | .06847 | 14.6059 | 5 |
| 56 | .01629 | 61.3829 | .03376 | 29.6245 | .05124 | 19.5156 | .06876 | 14.5438 | 4 |
| 57 | .01658 | 60.3058 | .03405 | 29.3711 | .05153 | 19.4051 | .06905 | 14.4823 | 3 |
| 58 | .01687 | 59.2659 | .03434 | 29.1220 | .05182 | 19.2959 | .06934 | 14.4212 | 2 |
| 59 | .01716 | 58.2612 | .03463 | 28.8771 | .05212 | 19.1879 | .06963 | 14.3607 | 1 |
| 60 | .01746 | 57.2900 | .03492 | 28.6363 | .05241 | 19.0811 | .06993 | 14.3007 | 0 |
| M. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | M. |
| | 89° | | 88° | | 87° | | 86° | | |

| M. | 4° Tang. | 4° Cotang. | 5° Tang. | 5° Cotang. | 6° Tang. | 6° Cotang. | 7° Tang. | 7° Cotang. | M. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | .06993 | 14.3007 | .08749 | 11.4301 | .10510 | 9.51436 | .12278 | 8.14435 | 60 |
| 1 | .07022 | 14.2411 | .08778 | 11.3919 | .10540 | 9.48781 | .12308 | 8.12481 | 59 |
| 2 | .07051 | 14.1821 | .08807 | 11.3540 | .10569 | 9.46141 | .12338 | 8.10536 | 58 |
| 3 | .07080 | 14.1235 | .08837 | 11.3163 | .10599 | 9.43515 | .12367 | 8.08600 | 57 |
| 4 | .07110 | 14.0655 | .08866 | 11.2789 | .10628 | 9.40904 | .12397 | 8.06674 | 56 |
| 5 | .07139 | 14.0079 | .08895 | 11.2417 | .10657 | 9.38307 | .12426 | 8.04756 | 55 |
| 6 | .07168 | 13.9507 | .08925 | 11.2048 | .10687 | 9.35724 | .12456 | 8.02848 | 54 |
| 7 | .07197 | 13.8940 | .08954 | 11.1681 | .10716 | 9.33155 | .12485 | 8.00948 | 53 |
| 8 | .07227 | 13.8378 | .08983 | 11.1316 | .10746 | 9.30599 | .12515 | 7.99058 | 52 |
| 9 | .07256 | 13.7821 | .09013 | 11.0954 | .10775 | 9.28058 | .12544 | 7.97176 | 51 |
| 10 | .07285 | 13.7267 | .09042 | 11.0594 | .10805 | 9.25530 | .12574 | 7.95302 | 50 |
| 11 | .07314 | 13.6719 | .09071 | 11.0237 | .10834 | 9.23016 | .12603 | 7.93438 | 49 |
| 12 | .07344 | 13.6174 | .09101 | 10.9882 | .10863 | 9.20516 | .12633 | 7.91582 | 48 |
| 13 | .07373 | 13.5634 | .09130 | 10.9529 | .10893 | 9.18028 | .12662 | 7.89734 | 47 |
| 14 | .07402 | 13.5098 | .09159 | 10.9178 | .10922 | 9.15554 | .12692 | 7.87895 | 46 |
| 15 | .07431 | 13.4566 | .09189 | 10.8829 | .10952 | 9.13093 | .12722 | 7.86064 | 45 |
| 16 | .07461 | 13.4039 | .09218 | 10.8483 | .10981 | 9.10646 | .12751 | 7.84245 | 44 |
| 17 | .07490 | 13.3515 | .09247 | 10.8139 | .11011 | 9.08211 | .12781 | 7.82428 | 43 |
| 18 | .07519 | 13.2996 | .09277 | 10.7797 | .11040 | 9.05789 | .12810 | 7.80622 | 42 |
| 19 | .07548 | 13.2480 | .09306 | 10.7457 | .11070 | 9.03379 | .12840 | 7.78825 | 41 |
| 20 | .07578 | 13.1969 | .09335 | 10.7119 | .11099 | 9.00983 | .12869 | 7.77035 | 40 |
| 21 | .07607 | 13.1461 | .09365 | 10.6783 | .11128 | 8.98598 | .12899 | 7.75254 | 39 |
| 22 | .07636 | 13.0958 | .09394 | 10.6450 | .11158 | 8.96227 | .12929 | 7.73480 | 38 |
| 23 | .07665 | 13.0458 | .09423 | 10.6118 | .11187 | 8.93867 | .12958 | 7.71715 | 37 |
| 24 | .07695 | 12.9962 | .09453 | 10.5789 | .11217 | 8.91520 | .12988 | 7.69957 | 36 |
| 25 | .07724 | 12.9469 | .09482 | 10.5462 | .11246 | 8.89185 | .13017 | 7.68208 | 35 |
| 26 | .07753 | 12.8981 | .09511 | 10.5136 | .11276 | 8.86862 | .13047 | 7.66466 | 34 |
| 27 | .07782 | 12.8496 | .09541 | 10.4813 | .11305 | 8.84551 | .13076 | 7.64732 | 33 |
| 28 | .07812 | 12.8014 | .09570 | 10.4491 | .11335 | 8.82252 | .13106 | 7.63005 | 32 |
| 29 | .07841 | 12.7536 | .09600 | 10.4172 | .11364 | 8.79964 | .13136 | 7.61287 | 31 |
| 30 | .07870 | 12.7062 | .09629 | 10.3854 | .11394 | 8.77689 | .13165 | 7.59575 | 30 |
| 31 | .07899 | 12.6591 | .09658 | 10.3538 | .11423 | 8.75425 | .13195 | 7.57872 | 29 |
| 32 | .07929 | 12.6124 | .09688 | 10.3224 | .11452 | 8.73172 | .13224 | 7.56176 | 28 |
| 33 | .07958 | 12.5660 | .09717 | 10.2913 | .11482 | 8.70931 | .13254 | 7.54487 | 27 |
| 34 | .07987 | 12.5199 | .09746 | 10.2602 | .11511 | 8.68701 | .13284 | 7.52806 | 26 |
| 35 | .08017 | 12.4742 | .09776 | 10.2294 | .11541 | 8.66482 | .13313 | 7.51132 | 25 |
| 36 | .08046 | 12.4288 | .09805 | 10.1988 | .11570 | 8.64275 | .13343 | 7.49465 | 24 |
| 37 | .08075 | 12.3838 | .09834 | 10.1683 | .11600 | 8.62078 | .13372 | 7.47806 | 23 |
| 38 | .08104 | 12.3390 | .09864 | 10.1381 | .11629 | 8.59893 | .13402 | 7.46154 | 22 |
| 39 | .08134 | 12.2946 | .09893 | 10.1080 | .11659 | 8.57718 | .13432 | 7.44509 | 21 |
| 40 | .08163 | 12.2505 | .09923 | 10.0780 | .11688 | 8.55555 | .13461 | 7.42871 | 20 |
| 41 | .08192 | 12.2067 | .09952 | 10.0483 | .11718 | 8.53402 | .13491 | 7.41240 | 19 |
| 42 | .08221 | 12.1632 | .09981 | 10.0187 | .11747 | 8.51259 | .13521 | 7.39616 | 18 |
| 43 | .08251 | 12.1201 | .10011 | 9.98931 | .11777 | 8.49128 | .13550 | 7.37999 | 17 |
| 44 | .08280 | 12.0772 | .10040 | 9.96007 | .11806 | 8.47007 | .13580 | 7.36389 | 16 |
| 45 | .08309 | 12.0346 | .10069 | 9.93101 | .11836 | 8.44896 | .13609 | 7.34786 | 15 |
| 46 | .08339 | 11.9923 | .10099 | 9.90211 | .11865 | 8.42795 | .13639 | 7.33190 | 14 |
| 47 | .08368 | 11.9504 | .10128 | 9.87338 | .11895 | 8.40705 | .13669 | 7.31600 | 13 |
| 48 | .08397 | 11.9087 | .10158 | 9.84482 | .11924 | 8.38625 | .13698 | 7.30018 | 12 |
| 49 | .08427 | 11.8673 | .10187 | 9.81641 | .11954 | 8.36555 | .13728 | 7.28442 | 11 |
| 50 | .08456 | 11.8262 | .10216 | 9.78817 | .11983 | 8.34496 | .13758 | 7.26873 | 10 |
| 51 | .08485 | 11.7853 | .10246 | 9.76009 | .12013 | 8.32446 | .13787 | 7.25310 | 9 |
| 52 | .08514 | 11.7448 | .10275 | 9.73217 | .12042 | 8.30406 | .13817 | 7.23754 | 8 |
| 53 | .08544 | 11.7045 | .10305 | 9.70441 | .12072 | 8.28376 | .13846 | 7.22204 | 7 |
| 54 | .08573 | 11.6645 | .10334 | 9.67680 | .12101 | 8.26355 | .13876 | 7.20661 | 6 |
| 55 | .08602 | 11.6248 | .10363 | 9.64935 | .12131 | 8.24345 | .13906 | 7.19125 | 5 |
| 56 | .08632 | 11.5853 | .10393 | 9.62205 | .12160 | 8.22344 | .13935 | 7.17594 | 4 |
| 57 | .08661 | 11.5461 | .10422 | 9.59490 | .12190 | 8.20352 | .13965 | 7.16071 | 3 |
| 58 | .08690 | 11.5072 | .10452 | 9.56791 | .12219 | 8.18370 | .13995 | 7.14553 | 2 |
| 59 | .08720 | 11.4685 | .10481 | 9.54106 | .12249 | 8.16398 | .14024 | 7.13042 | 1 |
| 60 | .08749 | 11.4301 | .10510 | 9.51436 | .12278 | 8.14435 | .14054 | 7.11537 | 0 |
| M. | Cotanv. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | M. |
| | 85° | | 84° | | 83° | | 82° | | |

| M. | 8° Tang. | 8° Cotang. | 9° Tang. | 9° Cotang. | 10° Tang. | 10° Cotang. | 11° Tang. | 11° Cotang. | M. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | .14 54 | 7.11537 | .15838 | 6.31375 | .17633 | 5.67128 | .19438 | 5.14455 | 60 |
| 1 | .14084 | 7.10038 | .15868 | 6.30189 | .17663 | 5.66165 | .19468 | 5.13658 | 59 |
| 2 | .14113 | 7.08546 | .15898 | 6.29007 | .17693 | 5.65205 | .19498 | 5.12862 | 58 |
| 3 | .14143 | 7.07059 | .15928 | 6.27829 | .17723 | 5.64248 | .19529 | 5.12069 | 57 |
| 4 | .14173 | 7.05579 | .15958 | 6.26655 | .17753 | 5.63295 | .19559 | 5.11279 | 56 |
| 5 | .14202 | 7.04105 | .15988 | 6.25486 | .17783 | 5.62344 | .19589 | 5.10490 | 55 |
| 6 | .14232 | 7.02637 | .16017 | 6.24321 | .17813 | 5.61397 | .19619 | 5.09704 | 54 |
| 7 | .14262 | 6.91174 | .16047 | 6.23160 | .17843 | 5.60452 | .19649 | 5.08921 | 53 |
| 8 | .14291 | 6.99718 | .16077 | 6.22003 | .17873 | 5.59511 | .19680 | 5.08139 | 52 |
| 9 | .14321 | 6.98268 | .16107 | 6.20851 | .17903 | 5.58573 | .19710 | 5.07360 | 51 |
| 10 | .14351 | 6.96823 | .16137 | 6.19703 | .17933 | 5.57638 | .19740 | 5.06584 | 50 |
| 11 | .14381 | 6.95385 | .16167 | 6.18559 | .17963 | 5.56706 | .19770 | 5.05809 | 49 |
| 12 | .14410 | 6.93952 | .16196 | 6.17419 | .17993 | 5.55777 | .19801 | 5.05037 | 48 |
| 13 | .14440 | 6.92525 | .16226 | 6.16283 | .18023 | 5 54851 | .19831 | 5.04267 | 47 |
| 14 | .14470 | 6.91104 | .16256 | 6.15151 | .18053 | 5.53927 | .19861 | 5.03499 | 46 |
| 15 | .14499 | 6.89688 | .16286 | 6.14023 | .18083 | 5.53007 | .19891 | 5.02734 | 45 |
| 16 | .14529 | 6.88278 | .16316 | 6.12899 | .18113 | 5.52090 | .19921 | 5.01971 | 44 |
| 17 | .14559 | 6.86874 | .16346 | 6.11779 | .18143 | 5.51176 | .19952 | 5.01210 | 43 |
| 18 | .14588 | 6.85475 | .16376 | 6.10664 | .18173 | 5.50264 | .19982 | 5.00451 | 42 |
| 19 | .14618 | 6.84082 | .16405 | 6.09552 | .18203 | 5.49356 | .20012 | 4.99695 | 41 |
| 20 | .14648 | 6.82694 | .16435 | 6.08444 | .18233 | 5.48451 | .20042 | 4.98940 | 40 |
| 21 | .14678 | 6.81312 | .16465 | 6.07340 | .18263 | 5.47548 | .20073 | 4.98188 | 39 |
| 22 | .14707 | 6.79936 | .16495 | 6.06240 | .18293 | 5.46648 | .20103 | 4.97438 | 38 |
| 23 | .14737 | 6.78564 | .16525 | 6.05143 | .18323 | 5.45751 | .20133 | 4.96690 | 37 |
| 24 | .14767 | 6.77199 | .16555 | 6.04051 | .18353 | 5.44857 | .20164 | 4.95945 | 36 |
| 25 | .14796 | 6.75838 | .16585 | 6.02962 | .18384 | 5.43966 | .20194 | 4.95201 | 35 |
| 26 | .14826 | 6.74483 | .16615 | 6.01878 | .18414 | 5.43077 | .20224 | 4.94460 | 34 |
| 27 | .14856 | 6.73133 | .16645 | 6.00797 | .18444 | 5.42192 | .20254 | 4.93721 | 33 |
| 28 | .14886 | 6.71789 | .16674 | 5.99720 | .18474 | 5.41309 | .20285 | 4.92984 | 32 |
| 29 | .14915 | 6.70450 | .16704 | 5.98646 | .18504 | 5.40429 | .20315 | 4.92249 | 31 |
| 30 | .14945 | 6.69116 | .16734 | 5.97576 | .18534 | 5.39552 | .20345 | 4.91516 | 30 |
| 31 | .14975 | 6.67787 | .16764 | 5.96510 | .18564 | 5.38677 | .20376 | 4.90785 | 29 |
| 32 | .15005 | 6.66463 | .16794 | 5.95448 | .18594 | 5.37805 | .20406 | 4.90056 | 28 |
| 33 | .15034 | 6.65144 | .16824 | 5.94390 | .18624 | 5.36936 | .20436 | 4.89330 | 27 |
| 34 | .15064 | 6.63831 | .16854 | 5.93335 | .18654 | 5.36070 | .20466 | 4.88605 | 26 |
| 35 | .15094 | 6.62523 | .16884 | 5.92283 | .18684 | 5.35206 | .20497 | 4.87882 | 25 |
| 36 | .15124 | 6.61219 | .16914 | 5.91236 | .18714 | 5.34345 | .20527 | 4.87162 | 24 |
| 37 | .15153 | 6.59921 | .16944 | 5.90191 | .18745 | 5.33487 | .20557 | 4.86444 | 23 |
| 38 | .15183 | 6.58627 | .16974 | 5.89151 | .18775 | 5.32631 | .20588 | 4.85727 | 22 |
| 39 | .15213 | 6.57339 | .17004 | 5.88114 | .18805 | 5.31778 | .20618 | 4.85013 | 21 |
| 40 | .15243 | 6.56055 | .17033 | 5.87080 | .18835 | 5.30928 | .20648 | 4.84300 | 20 |
| 41 | .15272 | 6.54777 | .17063 | 5.86051 | .18865 | 5.30080 | .20679 | 4.83590 | 19 |
| 42 | .15302 | 6.53503 | .17093 | 5.85024 | .18895 | 5.29235 | .20709 | 4.82882 | 18 |
| 43 | .15332 | 6.52234 | .17123 | 5.84001 | .18925 | 5.28393 | .20739 | 4.82175 | 17 |
| 44 | .15362 | 6.50970 | .17153 | 5.82982 | .18955 | 5.27553 | .20770 | 4.81471 | 16 |
| 45 | .15391 | 6.49710 | .17183 | 5.81966 | .18986 | 5.26715 | .20800 | 4.80769 | 15 |
| 46 | .15421 | 6.48456 | .17213 | 5.80953 | .19016 | 5.25880 | .20830 | 4.80068 | 14 |
| 47 | .15451 | 6.47206 | .17243 | 5.79944 | .19046 | 5.25048 | .20861 | 4.79370 | 13 |
| 48 | .15481 | 6.45961 | .17273 | 5.78938 | .19076 | 5.24218 | .20891 | 4.78673 | 12 |
| 49 | .15511 | 6.44720 | .17303 | 5.77936 | .19106 | 5.23391 | .20921 | 4.77978 | 11 |
| 50 | .15540 | 6.43484 | .17333 | 5.76937 | .19136 | 5.22566 | .20952 | 4.77286 | 10 |
| 51 | .15570 | 6.42253 | .17363 | 5.75941 | .19166 | 5.21744 | .20982 | 4.76595 | 9 |
| 52 | .15600 | 6.41026 | .17393 | 5.74949 | .19197 | 5.20925 | .21013 | 4.75906 | 8 |
| 53 | .15630 | 6.39804 | .17423 | 5.73960 | .19227 | 5.20107 | .21043 | 4.75219 | 7 |
| 54 | .15660 | 6.38587 | .17453 | 5.72974 | .19257 | 5.19293 | .21073 | 4.74534 | 6 |
| 55 | .15689 | 6.37374 | .17483 | 5.71992 | .19287 | 5.18480 | .21104 | 4.73851 | 5 |
| 56 | .15719 | 6.36165 | .17513 | 5.71013 | .19317 | 5.17671 | .21134 | 4.73170 | 4 |
| 57 | .15749 | 6.34961 | .17543 | 5.70037 | .19347 | 5.16863 | .21164 | 4.72490 | 3 |
| 58 | .15779 | 6.33761 | .17573 | 5.69064 | .19378 | 5.16058 | .21195 | 4.71813 | 2 |
| 59 | .15809 | 6.32566 | .17603 | 5.68094 | .19408 | 5.15256 | .21225 | 4.71137 | 1 |
| 60 | .15838 | 6.31375 | .17633 | 5.67128 | .19438 | 5.14455 | .21256 | 4.70463 | 0 |
| M. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | M. |
| | 81° | | 80° | | 79° | | 78° | | |

| M. | 12° | | 13° | | 14° | | 15° | | M. |
|---|---|---|---|---|---|---|---|---|---|
| | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | |
| 0 | .21256 | 4.70463 | .23087 | 4.33148 | .24933 | 4.01078 | .26795 | 3.73205 | 60 |
| 1 | .21286 | 4.69791 | .23117 | 4.32573 | .24964 | 4.00582 | .26826 | 3.72771 | 59 |
| 2 | .21316 | 4.69121 | .23148 | 4.32001 | .24995 | 4.00086 | .26857 | 3.72338 | 58 |
| 3 | .21347 | 4.68452 | .23179 | 4.31430 | .25026 | 3.99592 | .26888 | 3.71907 | 57 |
| 4 | .21377 | 4.67786 | .23209 | 4.30860 | .25056 | 3.99099 | .26920 | 3.71476 | 56 |
| 5 | .21408 | 4.67121 | .23240 | 4.30291 | .25087 | 3.98607 | .26951 | 3.71046 | 55 |
| 6 | .21438 | 4.66458 | .23271 | 4.29724 | .25118 | 3.98117 | .26982 | 3.70616 | 54 |
| 7 | .21469 | 4.65797 | .23301 | 4.29159 | .25149 | 3.97627 | .27013 | 3.70188 | 53 |
| 8 | .21499 | 4.65138 | .23332 | 4.28595 | .25180 | 3.97139 | .27044 | 3.69761 | 52 |
| 9 | .21529 | 4.64480 | .23363 | 4.28032 | .25211 | 3.96651 | .27076 | 3.69335 | 51 |
| 10 | .21560 | 4.63825 | .23393 | 4.27471 | .25242 | 3.96165 | .27107 | 3.68909 | 50 |
| 11 | .21590 | 4.63171 | .23424 | 4.26911 | .25273 | 3.95680 | .27138 | 3.68485 | 49 |
| 12 | .21621 | 4.62518 | .23455 | 4.26352 | .25304 | 3.95196 | .27169 | 3.68061 | 48 |
| 13 | .21651 | 4.61868 | .23485 | 4.25795 | .25335 | 3.94713 | .27201 | 3.67638 | 47 |
| 14 | .21682 | 4.61219 | .23516 | 4.25239 | .25366 | 3.94232 | .27232 | 3.67217 | 46 |
| 15 | .21712 | 4.60572 | .23547 | 4.24685 | .25397 | 3.93751 | .27263 | 3.66796 | 45 |
| 16 | .21743 | 4.59927 | .23578 | 4.24132 | .25428 | 3.93271 | .27294 | 3.66376 | 44 |
| 17 | .21773 | 4.59283 | .23608 | 4.23580 | .25459 | 3.92793 | .27326 | 3.65957 | 43 |
| 18 | .21804 | 4.58641 | .23639 | 4.23030 | .25490 | 3.92316 | .27357 | 3.65538 | 42 |
| 19 | .21834 | 4.58001 | .23670 | 4.22481 | .25521 | 3.91839 | .27388 | 3.65121 | 41 |
| 20 | .21864 | 4.57363 | .23700 | 4.21933 | .25552 | 3.91364 | .27419 | 3.64705 | 40 |
| 21 | .21895 | 4.56726 | .23731 | 4.21387 | .25583 | 3.90890 | .27451 | 3.64289 | 39 |
| 22 | .21925 | 4.56091 | .23762 | 4.20842 | .25614 | 3.90417 | .27482 | 3.63874 | 38 |
| 23 | .21956 | 4.55458 | .23793 | 4.20298 | .25645 | 3.89945 | .27513 | 3.63461 | 37 |
| 24 | .21986 | 4.54826 | .23823 | 4.19756 | .25676 | 3.89474 | .27545 | 3.63048 | 36 |
| 25 | .22017 | 4.54196 | .23854 | 4.19215 | .25707 | 3.89004 | .27576 | 3.62636 | 35 |
| 26 | .22047 | 4.53568 | .23885 | 4.18675 | .25738 | 3.88536 | .27607 | 3.62224 | 34 |
| 27 | .22078 | 4.52941 | .23916 | 4.18137 | .25769 | 3.88068 | .27638 | 3.61814 | 33 |
| 28 | .22108 | 4.52316 | .23946 | 4.17600 | .25800 | 3.87601 | .27670 | 3.61405 | 32 |
| 29 | .22139 | 4.51693 | .23977 | 4.17064 | .25831 | 3.87136 | .27701 | 3.60996 | 31 |
| 30 | .22169 | 4.51071 | .24008 | 4.16530 | .25862 | 3.86671 | .27732 | 3.60588 | 30 |
| 31 | .22200 | 4.50451 | .24039 | 4.15997 | .25893 | 3.86208 | .27764 | 3.60181 | 29 |
| 32 | .22231 | 4.49832 | .24069 | 4.15465 | .25924 | 3.85745 | .27795 | 3.59775 | 28 |
| 33 | .22261 | 4.49215 | .24100 | 4.14934 | .25955 | 3.85284 | .27826 | 3.59370 | 27 |
| 34 | .22292 | 4.48600 | .24131 | 4.14405 | .25986 | 3.84824 | .27858 | 3.58966 | 26 |
| 35 | .22322 | 4.47986 | .24162 | 4.13877 | .26017 | 3.84364 | .27889 | 3.58562 | 25 |
| 36 | .22353 | 4.47374 | .24193 | 4.13350 | .26048 | 3.83906 | .27921 | 3.58160 | 24 |
| 37 | .22383 | 4.46764 | .24223 | 4.12825 | .26079 | 3.83449 | .27952 | 3.57758 | 23 |
| 38 | .22414 | 4.46155 | .24254 | 4.12301 | .26110 | 3.82992 | .27983 | 3.57357 | 22 |
| 39 | .22444 | 4.45548 | .24285 | 4.11778 | .26141 | 3.82537 | .28015 | 3.56957 | 21 |
| 40 | .22475 | 4.44942 | .24316 | 4.11256 | .26172 | 3.82083 | .28046 | 3.56557 | 20 |
| 41 | .22505 | 4.44338 | .24347 | 4.10736 | .26203 | 3.81630 | .28077 | 3.56159 | 19 |
| 42 | .22536 | 4.43735 | .24377 | 4.10216 | .26235 | 3.81177 | .28109 | 3.55761 | 18 |
| 43 | .22567 | 4.43134 | .24408 | 4.09699 | .26266 | 3.80726 | .28140 | 3.55364 | 17 |
| 44 | .22597 | 4.42534 | .24439 | 4.09182 | .26297 | 3.80276 | .28172 | 3.54968 | 16 |
| 45 | .22628 | 4.41936 | .24470 | 4.08666 | .26328 | 3.79827 | .28203 | 3.54573 | 15 |
| 46 | .22658 | 4.41340 | .24501 | 4.08152 | .26359 | 3.79378 | .28234 | 3.54179 | 14 |
| 47 | .22689 | 4.40745 | .24532 | 4.07639 | .26390 | 3.78931 | .28266 | 3.53785 | 13 |
| 48 | .22719 | 4.40152 | .24562 | 4.07127 | .26421 | 3.78485 | .28297 | 3.53393 | 12 |
| 49 | .22750 | 4.39560 | .24593 | 4.06616 | .26452 | 3.78040 | .28329 | 3.53001 | 11 |
| 50 | .22781 | 4.38969 | .24624 | 4.06107 | .26483 | 3.77595 | .28360 | 3.52609 | 10 |
| 51 | .22811 | 4.38381 | .24655 | 4.05599 | .26515 | 3.77152 | .28391 | 3.52219 | 9 |
| 52 | .22842 | 4.37793 | .24686 | 4.05092 | .26546 | 3.76709 | .28423 | 3.51829 | 8 |
| 53 | .22872 | 4.37207 | .24717 | 4.04586 | .26577 | 3.76268 | .28454 | 3.51441 | 7 |
| 54 | .22903 | 4.36623 | .24747 | 4.04081 | .26608 | 3.75828 | .28486 | 3.51053 | 6 |
| 55 | .22934 | 4.36040 | .24778 | 4.03578 | .26639 | 3.75388 | .28517 | 3.50666 | 5 |
| 56 | .22964 | 4.35459 | .24809 | 4.03076 | .26670 | 3.74950 | .28549 | 3.50279 | 4 |
| 57 | .22995 | 4.34879 | .24840 | 4.02574 | .26701 | 3.74512 | .28580 | 3.49894 | 3 |
| 58 | .23026 | 4.34300 | .24871 | 4.02074 | .26733 | 3.74075 | .28612 | 3.49509 | 2 |
| 59 | .23056 | 4.33723 | .24902 | 4.01576 | .26764 | 3.73640 | .28643 | 3.49125 | 1 |
| 60 | .23087 | 4.33148 | .24933 | 4.01078 | .26795 | 3.73205 | .28675 | 3.48741 | 0 |
| M. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | M. |
| | 77° | | 76° | | 75° | | 74° | | |

| M. | 16° Tang. | 16° Cotang. | 17° Tang. | 17° Cotang. | 18° Tang. | 18° Cotang. | 19° Tang. | 19° Cotang. | M. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | .28675 | 3.48741 | .30573 | 3.27085 | .32492 | 3.07768 | .34433 | 2.90421 | 60 |
| 1 | .28706 | 3.48359 | .30605 | 3.26745 | .32524 | 3.07464 | .34465 | 2.90147 | 59 |
| 2 | .28738 | 3.47977 | .30637 | 3.26406 | .32556 | 3.07160 | .34498 | 2.89878 | 58 |
| 3 | .28769 | 3.47596 | .30669 | 3.26067 | .32588 | 3.06857 | .34530 | 2.89600 | 57 |
| 4 | .28800 | 3.47216 | .30700 | 3.25729 | .32621 | 3.06554 | .34563 | 2.89327 | 56 |
| 5 | .28832 | 3.46837 | .30732 | 3.25392 | .32653 | 3.06252 | .34596 | 2.89055 | 55 |
| 6 | .28864 | 3.46458 | .30764 | 3.25055 | .32685 | 3.05950 | .34628 | 2.88783 | 54 |
| 7 | .28895 | 3.46080 | .30796 | 3.24719 | .32717 | 3.05649 | .34661 | 2.88511 | 53 |
| 8 | .28927 | 3.45703 | .30828 | 3.24383 | .32749 | 3.05349 | .34693 | 2.88240 | 52 |
| 9 | .28958 | 3.45327 | .30860 | 3.24049 | .32782 | 3.05049 | .34726 | 2.87970 | 51 |
| 10 | .28990 | 3.44951 | .30891 | 3.23714 | .32814 | 3.04749 | .34758 | 2.87700 | 50 |
| 11 | .29021 | 3.44576 | .30923 | 3.23381 | .32846 | 3.04450 | .34791 | 2.87430 | 49 |
| 12 | .29053 | 3.44202 | .30955 | 3.23048 | .32878 | 3.04152 | .34824 | 2.87161 | 48 |
| 13 | .29084 | 3.43829 | .30987 | 3.22715 | .32911 | 3.03854 | .34856 | 2.86892 | 47 |
| 14 | .29116 | 3.43456 | .31019 | 3.22384 | .32943 | 3.03556 | .34889 | 2.86624 | 46 |
| 15 | .29147 | 3.43084 | .31051 | 3.22053 | .32975 | 3.03260 | .34922 | 2.86356 | 45 |
| 16 | .29179 | 3.42713 | .31083 | 3.21722 | .33007 | 3.02963 | .34954 | 2.86089 | 44 |
| 17 | .29210 | 3.42343 | .31115 | 3.21392 | .33040 | 3.02667 | .34987 | 2.85822 | 43 |
| 18 | .29242 | 3.41973 | .31147 | 3.21063 | .33072 | 3.02372 | .35020 | 2.85555 | 42 |
| 19 | .29274 | 3.41604 | .31178 | 3.20734 | .33104 | 3.02077 | .35052 | 2.85289 | 41 |
| 20 | .29305 | 3.41236 | .31210 | 3.20406 | .33136 | 3.01783 | .35085 | 2.85023 | 40 |
| 21 | .29337 | 3.40869 | .31242 | 3.20079 | .33169 | 3.01489 | .35118 | 2.84758 | 39 |
| 22 | .29368 | 3.40502 | .31274 | 3.19752 | .33201 | 3.01196 | .35150 | 2.84494 | 38 |
| 23 | .29400 | 3.40136 | .31306 | 3.19426 | .33233 | 3.00903 | .35183 | 2.84229 | 37 |
| 24 | .29432 | 3.39771 | .31338 | 3.19100 | .33266 | 3.00611 | .35216 | 2.83965 | 36 |
| 25 | .29463 | 3.39406 | .31370 | 3.18775 | .33298 | 3.00319 | .35248 | 2.83702 | 35 |
| 26 | .29495 | 3.39042 | .31402 | 3.18451 | .33330 | 3.00028 | .35281 | 2.83439 | 34 |
| 27 | .29526 | 3.38679 | .31434 | 3.18127 | .33363 | 2.99738 | .35314 | 2.83176 | 33 |
| 28 | .29558 | 3.38317 | .31466 | 3.17804 | .33395 | 2.99447 | .35346 | 2.82914 | 32 |
| 29 | .29590 | 3.37955 | .31498 | 3.17481 | .33427 | 2.99158 | .35379 | 2.82653 | 31 |
| 30 | .29621 | 3.37594 | .31530 | 3.17159 | .33460 | 2.98868 | .35412 | 2.82391 | 30 |
| 31 | .29653 | 3.37234 | .31562 | 3.16838 | .33492 | 2.98580 | .35445 | 2.82130 | 29 |
| 32 | .29685 | 3.36875 | .31594 | 3.16517 | .33524 | 2.98292 | .35477 | 2.81870 | 28 |
| 33 | .29716 | 3.36516 | .31626 | 3.16197 | .33557 | 2.98004 | .35510 | 2.81610 | 27 |
| 34 | .29748 | 3.36158 | .31658 | 3.15877 | .33589 | 2.97717 | .35543 | 2.81350 | 26 |
| 35 | .29780 | 3.35800 | .31690 | 3.15558 | .33621 | 2.97430 | .35576 | 2.81091 | 25 |
| 36 | .29811 | 3.35443 | .31722 | 3.15240 | .33654 | 2.97144 | .35608 | 2.80833 | 24 |
| 37 | .29843 | 3.35087 | .31754 | 3.14922 | .33686 | 2.96858 | .35641 | 2.80574 | 23 |
| 38 | .29875 | 3.34732 | .31786 | 3.14605 | .33718 | 2.96573 | .35674 | 2.80316 | 22 |
| 39 | .29906 | 3.34377 | .31818 | 3.14288 | .33751 | 2.96288 | .35707 | 2.80059 | 21 |
| 40 | .29938 | 3.34023 | .31850 | 3.13972 | .33783 | 2.96004 | .35740 | 2.79802 | 20 |
| 41 | .29970 | 3.33670 | .31882 | 3.13656 | .33816 | 2.95721 | .35772 | 2.79545 | 19 |
| 42 | .30001 | 3.33317 | .31914 | 3.13341 | .33848 | 2.95437 | .35805 | 2.79289 | 18 |
| 43 | .30033 | 3.32965 | .31946 | 3.13027 | .33881 | 2.95155 | .35838 | 2.79033. | 17 |
| 44 | .30065 | 3.32614 | .31978 | 3.12713 | .33913 | 2.94872 | .35871 | 2.78778 | 16 |
| 45 | .30097 | 3.32264 | .32010 | 3.12400 | .33945 | 2.94591 | .35904 | 2.78523 | 15 |
| 46 | .30128 | 3.31914 | .32042 | 3.12087 | .33978 | 2.94309 | .35937 | 2.78269 | 14 |
| 47 | .30160 | 3.31565 | .32074 | 3.11775 | .34010 | 2.94028 | .35969 | 2.78014 | 13 |
| 48 | .30192 | 3.31216 | .32106 | 3.11464 | .34043 | 2.93748 | .36002 | 2.77761 | 12 |
| 49 | .30224 | 3.30868 | .32139 | 3.11153 | .34075 | 2.93468 | .36035 | 2.77507 | 11 |
| 50 | .30255 | 3.30521 | .32171 | 3.10842 | .34108 | 2.93189 | .36068 | 2.77254 | 10 |
| 51 | .30287 | 3.30174 | .32203 | 3.10532 | .34140 | 2.92910 | .36101 | 2.77002 | 9 |
| 52 | .30319 | 3.29829 | .32235 | 3.10223 | .34173 | 2.92632 | .36134 | 2.76750 | 8 |
| 53 | .30351 | 3.29483 | .32267 | 3.09914 | .34205 | 2.92354 | .36167 | 2.76498 | 7 |
| 54 | .30382 | 3.29139 | .32299 | 3.09606 | .34238 | 2.92076 | .36199 | 2.76247 | 6 |
| 55 | .30414 | 3.28795 | .32331 | 3.09298 | .34270 | 2.91799 | .36232 | 2.75996 | 5 |
| 56 | .30446 | 3.28452 | .32363 | 3.08991 | .34303 | 2.91523 | .36265 | 2.75746 | 4 |
| 57 | .30478 | 3.28109 | .32396 | 3.08685 | .34335 | 2.91246 | .36298 | 2.75496 | 3 |
| 58 | .30509 | 3.27767 | .32428 | 3.08379 | .34368 | 2.90971 | .36331 | 2.75246 | 2 |
| 59 | .30541 | 3.27426 | .32460 | 3.08073 | .34400 | 2.90696 | .36364 | 2.74997 | 1 |
| 60 | .30573 | 3.27085 | .32492 | 3.07768 | .34433 | 2.90421 | .36397 | 2.74748 | 0 |
| M. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | M. |
| | 73° | | 72° | | 71° | | 70° | | |

| M. | 20° Tang. | 20° Cotang. | 21° Tang. | 21° Cotang. | 22° Tang. | 22° Cotang. | 23° Tang. | 23° Cotang. | M. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | .36397 | 2.74748 | .38386 | 2.60509 | .40403 | 2.47509 | .42447 | 2.35585 | 60 |
| 1 | .36430 | 2.74499 | .38420 | 2.60283 | .40436 | 2.47302 | .42482 | 2.35395 | 59 |
| 2 | .36463 | 2.74251 | .38453 | 2.60057 | .40470 | 2.47095 | .42516 | 2.35205 | 58 |
| 3 | .36496 | 2.74004 | .38487 | 2.59831 | .40504 | 2.46888 | .42551 | 2.35015 | 57 |
| 4 | .36529 | 2.73756 | .38520 | 2.59606 | .40538 | 2.46682 | .42585 | 2.34825 | 56 |
| 5 | .36562 | 2.73509 | .38553 | 2.59381 | .40572 | 2.46476 | .42619 | 2.34636 | 55 |
| 6 | .36595 | 2.73263 | .38587 | 2.59156 | .40606 | 2.46270 | .42654 | 2.34447 | 54 |
| 7 | .36628 | 3.73017 | .38620 | 2.58932 | .40640 | 2.46065 | .42688 | 2.34258 | 53 |
| 8 | .36661 | 2.72771 | .38654 | 2.58708 | .40674 | 2.45860 | .42722 | 2.34069 | 52 |
| 9 | .36694 | 2.72526 | .38687 | 2.58184 | .40707 | 2.45655 | .42757 | 2.33881 | 51 |
| 10 | .36727 | 2.72281 | .38721 | 2.58261 | .40741 | 2.45451 | .42791 | 2.33693 | 50 |
| 11 | .36760 | 2.72036 | .38754 | 2.58038 | .40775 | 2.45246 | .42826 | 2.33505 | 49 |
| 12 | .36793 | 2.71792 | .38787 | 2.57815 | .40809 | 2.45043 | .42860 | 2.33317 | 48 |
| 13 | .36826 | 2.71548 | .38821 | 2.57593 | .40843 | 2.44839 | .42894 | 2.33130 | 47 |
| 14 | .36859 | 2.71305 | .38854 | 2.57371 | .40877 | 2.44636 | .42929 | 2.32945 | 46 |
| 15 | .36892 | 2.71062 | .38888 | 2.57150 | .40911 | 2.44433 | .42963 | 2.32756 | 45 |
| 16 | .36925 | 2.70819 | .38921 | 2.56928 | .40945 | 2.44230 | .42998 | 2.32570 | 44 |
| 17 | .36958 | 2.70577 | .38955 | 2.56707 | .40979 | 2.44027 | .43032 | 2.32383 | 43 |
| 18 | .35991 | 2.70335 | .38988 | 2.56487 | .41013 | 2.43825 | .43067 | 2.32197 | 42 |
| 19 | .37024 | 2.70094 | .39022 | 2.56266 | .41047 | 2.43623 | .43101 | 2.32012 | 41 |
| 20 | .37057 | 2.69853 | .39055 | 2.56046 | .41081 | 2.43422 | .43136 | 2.31826 | 40 |
| 21 | .37090 | 2.69612 | .39089 | 2.55827 | .41115 | 2.43220 | .43170 | 2.31641 | 39 |
| 22 | .37123 | 2.69371 | .39122 | 2.55608 | .41149 | 2.43019 | .43205 | 2.31456 | 38 |
| 23 | .37157 | 2.69131 | .39156 | 2.55389 | .41183 | 2.42819 | .43239 | 2.31271 | 37 |
| 24 | .37190 | 2.68892 | .39190 | 2.55170 | .41217 | 2.42618 | .43274 | 2.31086 | 36 |
| 25 | .37223 | 2.68653 | .39223 | 2.54952 | .41251 | 2.42418 | .43308 | 2.30902 | 35 |
| 26 | .37256 | 2.68414 | .39257 | 2.54734 | .41285 | 2.42218 | .43343 | 2.30718 | 34 |
| 27 | .37289 | 2.68175 | .39290 | 2.54516 | .41319 | 2.42019 | .43378 | 2.30534 | 33 |
| 28 | .37322 | 2.67937 | .39324 | 2.54299 | .41353 | 2.41819 | .43412 | 2.30351 | 32 |
| 29 | .37355 | 2.67700 | .39357 | 2.54082 | .41387 | 2.41620 | .43447 | 2.30167 | 31 |
| 30 | .37388 | 2.67462 | .39391 | 2.53865 | .41421 | 2.41421 | .43481 | 2.29984 | 30 |
| 31 | .37422 | 2.67225 | .39425 | 2.53648 | .41455 | 2.41223 | .43516 | 2.29801 | 29 |
| 32 | .37455 | 2.66989 | .39458 | 2.53432 | .41490 | 2.41025 | .43550 | 2.29619 | 28 |
| 33 | .37488 | 2.66752 | .39492 | 2.53217 | .41524 | 2.40827 | .43585 | 2.29437 | 27 |
| 34 | .37521 | 2.66516 | .39526 | 2.53001 | .41558 | 2.40629 | .43620 | 2.29254 | 26 |
| 35 | .37554 | 2.66281 | .39559 | 2.52786 | .41592 | 2.40432 | .43654 | 2.29073 | 25 |
| 36 | .37588 | 2.66046 | .39593 | 2.52571 | .41626 | 2.40235 | .43689 | 2.28891 | 24 |
| 37 | .37621 | 2.65811 | .39626 | 2.52357 | .41660 | 2.40038 | .43724 | 2.28710 | 23 |
| 38 | .37654 | 2.65576 | .39660 | 2.52142 | .41694 | 2.39841 | .43758 | 2.28528 | 22 |
| 39 | .37687 | 2.65342 | .39694 | 2.51929 | .41728 | 2.39645 | .43793 | 2.28348 | 21 |
| 40 | .37720 | 2.65109 | .39727 | 2.51715 | .41763 | 2.39449 | .43828 | 2.28167 | 20 |
| 41 | .37754 | 2.64875 | .39761 | 2.51502 | .41797 | 2.39253 | .43862 | 2.27987 | 19 |
| 42 | .37787 | 2.64642 | .39795 | 2.51289 | .41831 | 2.39058 | .43897 | 2.27806 | 18 |
| 43 | .37820 | 2.64410 | .39829 | 2.51076 | .41865 | 2.38863 | .43932 | 2.27626 | 17 |
| 44 | .37853 | 2.64177 | .39862 | 2.50864 | .41899 | 2.38668 | .43966 | 2.27447 | 16 |
| 45 | .37887 | 2.63945 | .39896 | 2.50652 | .41933 | 2.38473 | .44001 | 2.27267 | 15 |
| 46 | .37920 | 2.63714 | .39930 | 2.50440 | .41968 | 2.38279 | .44036 | 2.27088 | 14 |
| 47 | .37953 | 2.63483 | .39963 | 2.50229 | .42002 | 2.38084 | .44071 | 2.26909 | 13 |
| 48 | .37986 | 2.63252 | .39997 | 2.50018 | .42036 | 2.37891 | .44105 | 2.26730 | 12 |
| 49 | .38020 | 2.63021 | .40031 | 2.49807 | .42070 | 2.37697 | .44140 | 2.26552 | 11 |
| 50 | .38053 | 2.62791 | .40065 | 2.49597 | .42105 | 2.37504 | .44175 | 2.26374 | 10 |
| 51 | .38086 | 2.62561 | .40098 | 2.49386 | .42139 | 2.37311 | .44210 | 2.26196 | 9 |
| 52 | .38120 | 2.62332 | .40132 | 2.49177 | .42173 | 2.37118 | .44244 | 2.26018 | 8 |
| 53 | .38153 | 2.62103 | .40166 | 2.48967 | .42207 | 2.36925 | .44279 | 2.25840 | 7 |
| 54 | .38186 | 2.61874 | .40200 | 2.48758 | .42242 | 2.36733 | .44314 | 2.25663 | 6 |
| 55 | .38220 | 2.61646 | .40234 | 2.48549 | .42276 | 2.36541 | .44349 | 2.25486 | 5 |
| 56 | .38253 | 2.61418 | .40267 | 2.48340 | .42310 | 2.36349 | .44384 | 2.25309 | 4 |
| 57 | .38286 | 2.61190 | .40301 | 2.48132 | .42345 | 2.36158 | .44418 | 2.25132 | 3 |
| 58 | .38320 | 2.60963 | .40335 | 2.47924 | .42379 | 2.35967 | .44453 | 2.24956 | 2 |
| 59 | .38353 | 2.60736 | .40369 | 2.47716 | .42413 | 2.35776 | .44488 | 2.24780 | 1 |
| 60 | .38386 | 2.60509 | .40403 | 2.47509 | .42447 | 2.35585 | .44523 | 2.24604 | 0 |
| M. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | M. |
| | 69° | | 68° | | 67° | | 66° | | |

| M. | 24° | | 25° | | 26° | | 27° | | M. |
|---|---|---|---|---|---|---|---|---|---|
| | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotant. | |
| 0 | .44523 | 2.24604 | .46631 | 2.14451 | .48773 | 2.05030 | .50953 | 1.96261 | 60 |
| 1 | .44558 | 2.24428 | .46666 | 2.14288 | .48809 | 2.04879 | .50989 | 1.96120 | 59 |
| 2 | .44593 | 2.24252 | .46702 | 2.14125 | .48845 | 2.04728 | .51026 | 1.95979 | 58 |
| 3 | .44627 | 2.24077 | .46737 | 2.13963 | .48881 | 2.04577 | .51063 | 1.95838 | 57 |
| 4 | .44662 | 2.23902 | .46772 | 2.13801 | .48917 | 2.04426 | .51099 | 1.95698 | 56 |
| 5 | .44697 | 2.23.27 | .46808 | 2.13639 | .48953 | 2.04276 | .51136 | 1.95557 | 55 |
| 6 | .44732 | 2.23553 | .46843 | 2.13477 | .48989 | 2.04125 | .51173 | 1.95417 | 54 |
| 7 | .44767 | 2.23378 | .46879 | 2.13316 | .49026 | 2.03975 | .51209 | 1.95277 | 53 |
| 8 | .44802 | 2.23204 | .46914 | 2.13154 | .49062 | 2.03825 | .51246 | 1.95137 | 52 |
| 9 | .44837 | 2.23030 | .46950 | 2.12993 | .49098 | 2.03675 | .51283 | 1.94997 | 51 |
| 10 | .44872 | 2.22857 | .46985 | 2.12832 | .49134 | 2.03526 | .51319 | 1.94858 | 50 |
| 11 | .44907 | 2.22683 | .47021 | 2.12671 | .49170 | 2.03376 | .51356 | 1.94718 | 49 |
| 12 | .44942 | 2.22510 | .47056 | 2.12511 | .49206 | 2.03227 | .51393 | 1.94579 | 48 |
| 13 | .44977 | 2.22337 | .47092 | 2.12350 | .49242 | 2.03078 | .51430 | 1.94440 | 47 |
| 14 | .45012 | 2.22164 | .47128 | 2.12190 | .49278 | 2.02929 | .51467 | 1.94301 | 46 |
| 15 | .45047 | 2.21992 | .47163 | 2.12030 | .49315 | 2.02780 | .51503 | 1.94162 | 45 |
| 16 | .45082 | 2.21819 | .47199 | 2.11871 | .49351 | 2.02631 | .51540 | 1.94023 | 44 |
| 17 | .45117 | 2.21647 | .47234 | 2.11711 | .49387 | 2.02483 | .51577 | 1.93885 | 43 |
| 18 | .45152 | 2.21475 | .47270 | 2.11552 | .49423 | 2.02335 | .51614 | 1.93746 | 42 |
| 19 | .45187 | 2.21304 | .47305 | 2.11392 | .49459 | 2.02187 | .51651 | 1.93608 | 41 |
| 20 | .45222 | 2.21132 | .47341 | 2.11233 | .49495 | 2.02039 | .51688 | 1.93470 | 40 |
| 21 | .45257 | 2.20961 | .47377 | 2.11075 | .49532 | 2.01891 | .51724 | 1.93332 | 39 |
| 22 | .45292 | 2.20790 | .47412 | 2.10916 | .49568 | 2.01743 | .51761 | 1.93195 | 38 |
| 23 | .45327 | 2.20619 | .47448 | 2.10758 | .49604 | 2.01596 | .51798 | 1.93057 | 37 |
| 24 | .45362 | 2.20449 | .47483 | 2.10600 | .49640 | 2.01449 | .51835 | 1.92920 | 36 |
| 25 | .45397 | 2.20278 | .47519 | 2.10442 | .49677 | 2.01302 | .51872 | 1.92782 | 35 |
| 26 | .45432 | 2.20108 | .47555 | 2.10284 | .49713 | 2.01155 | .51909 | 1.92645 | 34 |
| 27 | .45467 | 2.19938 | .47590 | 2.10126 | .49749 | 2.01008 | .51946 | 1.92508 | 33 |
| 28 | .45502 | 2.19769 | .47626 | 2.09969 | .49786 | 2.00862 | .51983 | 1.92371 | 32 |
| 29 | .45538 | 2.19599 | .47662 | 2.09811 | .49822 | 2.00715 | .52020 | 1.92235 | 31 |
| 30 | .45573 | 2.19430 | .47698 | 2.09654 | .49858 | 2.00569 | .52057 | 1.92098 | 30 |
| 31 | .45608 | 2.19261 | .47733 | 2.09498 | .49894 | 2.00423 | .52094 | 1.91962 | 29 |
| 32 | .45643 | 2.19092 | .47769 | 2.09341 | .49931 | 2.00277 | .52131 | 1.91826 | 28 |
| 33 | .45678 | 2.18923 | .47805 | 2.09184 | .49967 | 2.00131 | .52168 | 1.91690 | 27 |
| 34 | .45713 | 2.18755 | .47840 | 2.09028 | .50004 | 1.99986 | .52205 | 1.91554 | 26 |
| 35 | .45748 | 2.18587 | .47876 | 2.08872 | .50040 | 1.99841 | .52242 | 1.91418 | 25 |
| 36 | .45784 | 2.18419 | .47912 | 2.08716 | .50076 | 1.99695 | .52279 | 1.91282 | 24 |
| 37 | .45819 | 2.18251 | .47948 | 2.08560 | .50113 | 1.99550 | .52316 | 1.91147 | 23 |
| 38 | .45854 | 2.18084 | .47984 | 2.08405 | .50149 | 1.99406 | .52353 | 1.91012 | 22 |
| 39 | .45889 | 2.17916 | .48019 | 2.08250 | .50185 | 1.99261 | .52390 | 1.90876 | 21 |
| 40 | .45924 | 2.17749 | .48055 | 2.08094 | .50222 | 1.99116 | .52427 | 1.90741 | 20 |
| 41 | .45960 | 2.17582 | .48091 | 2.07939 | .50258 | 1.98972 | .52464 | 1.90607 | 19 |
| 42 | .45995 | 2.17416 | .48127 | 2.07785 | .50295 | 1.98828 | .52501 | 1.90472 | 18 |
| 43 | .46030 | 2.17249 | .48163 | 2.07630 | .50331 | 1.98684 | .52538 | 1.90337 | 17 |
| 44 | .46065 | 2.17083 | .48198 | 2.07476 | .50368 | 1.98540 | .52575 | 1.90203 | 16 |
| 45 | .46101 | 2.16917 | .48234 | 2.07321 | .50404 | 1.98396 | .52613 | 1.90069 | 15 |
| 46 | .46136 | 2.16751 | .48270 | 2.07167 | .50441 | 1.98253 | .52650 | 1.89935 | 14 |
| 47 | .46171 | 2.16585 | .48306 | 2.07014 | .50477 | 1.98110 | .52687 | 1.89801 | 13 |
| 48 | .46206 | 2.16420 | .48342 | 2.06860 | .50514 | 1.97966 | .52724 | 1.89667 | 12 |
| 49 | .46242 | 2.16255 | .48378 | 2.06706 | .50550 | 1.97823 | .52761 | 1.89533 | 11 |
| 50 | .46277 | 2.16090 | .48414 | 2.06553 | .50587 | 1.97681 | .52798 | 1.89400 | 10 |
| 51 | .46312 | 2.15925 | .48450 | 2.06400 | .50623 | 1.97538 | .52836 | 1.89266 | 9 |
| 52 | .46348 | 2.15760 | .48486 | 2.06247 | .50660 | 1.97395 | .52873 | 1.89133 | 8 |
| 53 | .46383 | 2.15596 | .48521 | 2.06094 | .50696 | 1.97253 | .52910 | 1.89000 | 7 |
| 54 | .46418 | 2.15432 | .48557 | 2.05942 | .50733 | 1.97111 | .52947 | 1.88867 | 6 |
| 55 | .46454 | 2.15268 | .48593 | 2.05790 | .50769 | 1.96969 | .52985 | 1.88734 | 5 |
| 56 | .46489 | 2.15104 | .48629 | 2.05637 | .50806 | 1.96827 | .53022 | 1.88602 | 4 |
| 57 | .46525 | 2.14940 | .48665 | 2.05485 | .50843 | 1.96685 | .53059 | 1.88469 | 3 |
| 58 | .46560 | 2.14777 | .48701 | 2.05333 | .50879 | 1.96544 | .53096 | 1.88337 | 2 |
| 59 | .46595 | 2.14614 | .48737 | 2.05182 | .50916 | 1.96402 | .53134 | 1.88205 | 1 |
| 60 | .46631 | 2.14451 | .48773 | 2.05030 | .50953 | 1.96261 | .53171 | 1.88073 | 0 |
| M. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | M. |
| | 65° | | 64° | | 63° | | 62° | | |

| M. | 28° | | 29° | | 30° | | 31° | | M. |
|---|---|---|---|---|---|---|---|---|---|
| | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | |
| 0 | .53171 | 1.88073 | .55431 | 1.80405 | .57735 | 1.73205 | .60086 | 1.66428 | 60 |
| 1 | .53208 | 1.87941 | .55469 | 1.80281 | .57774 | 1.73089 | .60126 | 1.66318 | 59 |
| 2 | .53246 | 1.87809 | .55507 | 1.80158 | .57813 | 1.72973 | .60165 | 1.66209 | 58 |
| 3 | .53283 | 1.87677 | .55545 | 1.80034 | .57851 | 1.72857 | .60205 | 1.66099 | 57 |
| 4 | .53320 | 1.87546 | .55583 | 1.79911 | .57890 | 1.72741 | .60245 | 1.65990 | 56 |
| 5 | .53358 | 1.87415 | .55621 | 1.79788 | .57929 | 1.72625 | .60284 | 1.65881 | 55 |
| 6 | .53395 | 1.87283 | .55659 | 1.79665 | .57968 | 1.72509 | .60324 | 1.65772 | 54 |
| 7 | .53432 | 1.87152 | .55697 | 1.79542 | .58007 | 1.72393 | .60364 | 1.65663 | 53 |
| 8 | .53470 | 1.87021 | .55736 | 1.79419 | .58046 | 1.72278 | .60403 | 1.65554 | 52 |
| 9 | .53507 | 1.86891 | .55774 | 1.79296 | .58085 | 1.72163 | .60443 | 1.65445 | 51 |
| 10 | .53545 | 1.86760 | .55812 | 1.79174 | .58124 | 1.72047 | .60483 | 1.65337 | 50 |
| 11 | .53582 | 1.86630 | .55850 | 1.79051 | .58162 | 1.71932 | .60522 | 1.65228 | 49 |
| 12 | .53620 | 1.86499 | .55888 | 1.78929 | .58201 | 1.71817 | .60562 | 1.65120 | 48 |
| 13 | .53657 | 1.86369 | .55926 | 1.78807 | .58240 | 1.71702 | .60602 | 1.65011 | 47 |
| 14 | .53694 | 1.86239 | .55964 | 1.78685 | .58279 | 1.71588 | .60642 | 1.64903 | 46 |
| 15 | .53732 | 1.86109 | .56003 | 1.78563 | .58318 | 1.71473 | .60681 | 1.64795 | 45 |
| 16 | .53769 | 1.85979 | .56041 | 1.78441 | .58357 | 1.71358 | .60721 | 1.64687 | 44 |
| 17 | .53807 | 1.85850 | .56079 | 1.78319 | .58396 | 1.71244 | .60761 | 1.64579 | 43 |
| 18 | .53844 | 1.85720 | .56117 | 1.78198 | .58435 | 1.71129 | .60801 | 1.64471 | 42 |
| 19 | .53882 | 1.85591 | .56156 | 1.78077 | .58474 | 1.71015 | .60841 | 1.64363 | 41 |
| 20 | .53920 | 1.85462 | .56194 | 1.77955 | .58513 | 1.70901 | .60881 | 1.64256 | 40 |
| 21 | .53957 | 1.85333 | .56232 | 1.77834 | .58552 | 1.70787 | .60921 | 1.64148 | 39 |
| 22 | .53995 | 1.85204 | .56270 | 1.77713 | .58591 | 1.70673 | .60960 | 1.64041 | 38 |
| 23 | .54032 | 1.85075 | .56309 | 1.77592 | .58631 | 1.70560 | .61000 | 1.63934 | 37 |
| 24 | .54070 | 1.84946 | .56347 | 1.77471 | .58670 | 1.70446 | .61040 | 1.63826 | 36 |
| 25 | .54107 | 1.84818 | .56385 | 1.77351 | .58709 | 1.70332 | .61080 | 1.63719 | 35 |
| 26 | .54145 | 1.84689 | .56424 | 1.77230 | .58748 | 1.70219 | .61120 | 1.63612 | 34 |
| 27 | .54183 | 1.84561 | .56462 | 1.77110 | .58787 | 1.70106 | .61160 | 1.63505 | 33 |
| 28 | .54220 | 1.84433 | .56501 | 1.76990 | .58826 | 1.69992 | .61200 | 1.63398 | 32 |
| 29 | .54258 | 1.84305 | .56539 | 1.76869 | .58865 | 1.69879 | .61240 | 1.63292 | 31 |
| 30 | .54296 | 1.84177 | .56577 | 1.76749 | .58905 | 1.69766 | .61280 | 1.63185 | 30 |
| 31 | .54333 | 1.84049 | .56616 | 1.76629 | .58944 | 1.69653 | .61320 | 1.63079 | 29 |
| 32 | .54371 | 1.83922 | .56654 | 1.76510 | .58983 | 1.69541 | .61360 | 1.62972 | 28 |
| 33 | .54409 | 1.83794 | .56693 | 1.76390 | .59022 | 1.69428 | .61400 | 1.62866 | 27 |
| 34 | .54446 | 1.83667 | .56731 | 1.76271 | .59061 | 1.69316 | .61440 | 1.62760 | 26 |
| 35 | .54484 | 1.83540 | .56769 | 1.76151 | .59101 | 1.69203 | .61480 | 1.62654 | 25 |
| 36 | .54522 | 1.83413 | .56808 | 1.76032 | .59140 | 1.69091 | .61520 | 1.62548 | 24 |
| 37 | .54560 | 1.83286 | .56846 | 1.75913 | .59179 | 1.68979 | .61561 | 1.62442 | 23 |
| 38 | .54597 | 1.83159 | .56885 | 1.75794 | .59218 | 1.68866 | .61601 | 1.62336 | 22 |
| 39 | .54635 | 1.83033 | .56923 | 1.75675 | .59258 | 1.68754 | .61641 | 1.62230 | 21 |
| 40 | .54673 | 1.82906 | .56962 | 1.75556 | .59297 | 1.68643 | .61681 | 1.62125 | 20 |
| 41 | .54711 | 1.82780 | .57000 | 1.75437 | .59336 | 1.68531 | .61721 | 1.62019 | 19 |
| 42 | .54748 | 1.82654 | .57039 | 1.75319 | .59376 | 1.68419 | .61761 | 1.61914 | 18 |
| 43 | .54786 | 1.82528 | .57078 | 1.75200 | .59415 | 1.68308 | .61801 | 1.61808 | 17 |
| 44 | .54824 | 1.82402 | .57116 | 1.75082 | .59454 | 1.68196 | .61842 | 1.61703 | 16 |
| 45 | .54862 | 1.82276 | .57155 | 1.74964 | .59494 | 1.68085 | .61882 | 1.61598 | 15 |
| 46 | .54900 | 1.82150 | .57193 | 1.74846 | .59533 | 1.67974 | .61922 | 1.61493 | 14 |
| 47 | .54938 | 1.82025 | .57232 | 1.74728 | .59573 | 1.67863 | .61962 | 1.61388 | 13 |
| 48 | .54975 | 1.81899 | .57271 | 1.74610 | .59612 | 1.67752 | .62003 | 1.61283 | 12 |
| 49 | .55013 | 1.81774 | .57309 | 1.74492 | .59651 | 1.67641 | .62043 | 1.61179 | 11 |
| 50 | .55051 | 1.81649 | .57348 | 1.74375 | .59691 | 1.67530 | .62083 | 1.61074 | 10 |
| 51 | .55089 | 1.81524 | .57386 | 1.74257 | .59730 | 1.67419 | .62124 | 1.60970 | 9 |
| 52 | .55127 | 1.81399 | .57425 | 1.74140 | .59770 | 1.67309 | .62164 | 1.60865 | 8 |
| 53 | .55165 | 1.81274 | .57464 | 1.74022 | .59809 | 1.67198 | .62204 | 1.60761 | 7 |
| 54 | .55203 | 1.81150 | .57503 | 1.73905 | .59849 | 1.67088 | .62245 | 1.60657 | 6 |
| 55 | .55241 | 1.81025 | .57541 | 1.73788 | .59888 | 1.66978 | .62285 | 1.60553 | 5 |
| 56 | .55279 | 1.80901 | .57580 | 1.73671 | .59928 | 1.66867 | .62325 | 1.60449 | 4 |
| 57 | .55317 | 1.80777 | .57619 | 1.73555 | .59967 | 1.66757 | .62366 | 1.60345 | 3 |
| 58 | .55355 | 1.80653 | .57657 | 1.73438 | .60007 | 1.66647 | .62406 | 1.60241 | 2 |
| 59 | .55393 | 1.80529 | .57696 | 1.73321 | .60046 | 1.66538 | .62446 | 1.60137 | 1 |
| 60 | .55431 | 1.80405 | .57735 | 1.73205 | .60086 | 1.66428 | .62487 | 1.60032 | 0 |
| M. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | M. |
| | 61° | | 60° | | 59° | | 58° | | |

| M. | 32° Tang. | 32° Cotang. | 33° Tang. | 33° Cotang. | 34° Tang. | 34° Cotang. | 35° Tang. | 35° Cotang. | M. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | .62487 | 1.60033 | .64941 | 1.53986 | .67451 | 1.48256 | .70021 | 1.42815 | 60 |
| 1 | .62527 | 1.59930 | .64982 | 1.53888 | .67493 | 1.48163 | .70064 | 1.42726 | 59 |
| 2 | .62568 | 1.59826 | .65024 | 1.53791 | .67536 | 1.48070 | .70107 | 1.42638 | 58 |
| 3 | .62608 | 1.59723 | .65065 | 1.53693 | .67578 | 1.47977 | .70151 | 1.42550 | 57 |
| 4 | .62649 | 1.59620 | .65106 | 1.53595 | .67620 | 1.47885 | .70194 | 1.42462 | 56 |
| 5 | .62689 | 1.59517 | .65148 | 1.53497 | .67663 | 1.47792 | .70238 | 1.42374 | 55 |
| 6 | .62730 | 1.59414 | .65189 | 1.53400 | .67705 | 1.47699 | .70283 | 1.42286 | 54 |
| 7 | .62770 | 1.59311 | .65231 | 1.53302 | .67748 | 1.47607 | .70325 | 1.42198 | 53 |
| 8 | .62811 | 1.59208 | .65272 | 1.53205 | .67790 | 1.47514 | .70368 | 1.42110 | 52 |
| 9 | .62852 | 1.59105 | .65314 | 1.53107 | .67832 | 1.47422 | .70412 | 1.42022 | 51 |
| 10 | .62892 | 1.59002 | .65355 | 1.53010 | .67875 | 1.47330 | .70455 | 1.41934 | 50 |
| 11 | .62933 | 1.58900 | .65397 | 1.52913 | .67917 | 1.47238 | .70499 | 1.41847 | 49 |
| 12 | .62973 | 1.58797 | .65438 | 1.52816 | .67960 | 1.47146 | .70542 | 1.41759 | 48 |
| 13 | .63014 | 1.58695 | .65480 | 1.52719 | .68002 | 1.47053 | .70586 | 1.41672 | 47 |
| 14 | .63055 | 1.58593 | .65521 | 1.52622 | .68045 | 1.46962 | .70629 | 1.41584 | 46 |
| 15 | .63095 | 1.58490 | .65563 | 1.52525 | .68088 | 1.46870 | .70673 | 1.41497 | 45 |
| 16 | .63136 | 1.58388 | .65604 | 1.52429 | .68130 | 1.46778 | .70717 | 1.41409 | 44 |
| 17 | .63177 | 1.58286 | .65646 | 1.52332 | .68173 | 1.46686 | .70760 | 1.41322 | 43 |
| 18 | .63217 | 1.58184 | .65688 | 1.52235 | .68215 | 1.46595 | .70804 | 1.41235 | 42 |
| 19 | .63258 | 1.58083 | .65729 | 1.52139 | .68258 | 1.46503 | .70848 | 1.41148 | 41 |
| 20 | .63299 | 1.57981 | .65771 | 1.52043 | .68301 | 1.46411 | .70891 | 1.41061 | 40 |
| 21 | .63340 | 1.57879 | .65813 | 1.51946 | .68343 | 1.46320 | .70935 | 1.40974 | 39 |
| 22 | .63380 | 1.57778 | .65854 | 1.51850 | .68386 | 1.46229 | .70979 | 1.40887 | 38 |
| 23 | .63421 | 1.57676 | .65896 | 1.51754 | .68429 | 1.46137 | .71023 | 1.40800 | 37 |
| 24 | .63462 | 1.57575 | .65938 | 1.51658 | .68471 | 1.46046 | .71066 | 1.40714 | 36 |
| 25 | .63503 | 1.57474 | .65980 | 1.51562 | .68514 | 1.45955 | .71110 | 1.40627 | 35 |
| 26 | .63544 | 1.57372 | .66021 | 1.51466 | .68557 | 1.45864 | .71154 | 1.40540 | 34 |
| 27 | .63584 | 1.57271 | .66063 | 1.51370 | .68600 | 1.45773 | .71198 | 1.40454 | 33 |
| 28 | .63625 | 1.57170 | .66105 | 1.51275 | .68642 | 1.45682 | .71242 | 1.40367 | 32 |
| 29 | .63666 | 1.57069 | .66147 | 1.51179 | .68685 | 1.45592 | .71285 | 1.40281 | 31 |
| 30 | .63707 | 1.56969 | .66189 | 1.51084 | .68728 | 1.45501 | .71329 | 1.40195 | 30 |
| 31 | .63748 | 1.56868 | .66230 | 1.50988 | .68771 | 1.45410 | .71373 | 1.40109 | 29 |
| 32 | .63789 | 1.56767 | .66272 | 1.50893 | .68814 | 1.45320 | .71417 | 1.40022 | 28 |
| 33 | .63830 | 1.56667 | .66314 | 1.50797 | .68857 | 1.45229 | .71461 | 1.39936 | 27 |
| 34 | .63871 | 1.56566 | .66356 | 1.50702 | .68900 | 1.45139 | .71505 | 1.39850 | 26 |
| 35 | .63912 | 1.56466 | .66398 | 1.50607 | .68942 | 1.45049 | .71549 | 1.39764 | 25 |
| 36 | .63953 | 1.56366 | .66440 | 1.50512 | .68985 | 1.44958 | .71593 | 1.39679 | 24 |
| 37 | .63994 | 1.56265 | .66482 | 1.50417 | .69028 | 1.44868 | .71637 | 1.39593 | 23 |
| 38 | .64035 | 1.56165 | .66524 | 1.50322 | .69071 | 1.44778 | .71681 | 1.39507 | 22 |
| 39 | .64076 | 1.56065 | .66566 | 1.50228 | .69114 | 1.44688 | .71725 | 1.39421 | 21 |
| 40 | .64117 | 1.55966 | .66608 | 1.50133 | .69157 | 1.44598 | .71769 | 1.39336 | 20 |
| 41 | .64158 | 1.55866 | .66650 | 1.50038 | .69200 | 1.44508 | .71813 | 1.39250 | 19 |
| 42 | .64199 | 1.55766 | .66692 | 1.49944 | .69243 | 1.44418 | .71857 | 1.39165 | 18 |
| 43 | .64240 | 1.55666 | .66734 | 1.49849 | .69286 | 1.44329 | .71901 | 1.39079 | 17 |
| 44 | .64281 | 1.55567 | .66776 | 1.49755 | .69329 | 1.44239 | .71946 | 1.38994 | 16 |
| 45 | .64322 | 1.55467 | .66818 | 1.49661 | .69372 | 1.44149 | .71990 | 1.38909 | 15 |
| 46 | .64363 | 1.55368 | .66860 | 1.49566 | .69416 | 1.44060 | .72034 | 1.38824 | 14 |
| 47 | .64404 | 1.55269 | .66902 | 1.49472 | .69459 | 1.43970 | .72078 | 1.38738 | 13 |
| 48 | .64446 | 1.55170 | .66944 | 1.49378 | .69502 | 1.43881 | .72122 | 1.38653 | 12 |
| 49 | .64487 | 1.55071 | .66986 | 1.49284 | .69545 | 1.43792 | .72167 | 1.38568 | 11 |
| 50 | .64528 | 1.54972 | .67028 | 1.49190 | .69588 | 1.43703 | .72211 | 1.38484 | 10 |
| 51 | .64569 | 1.54873 | .67071 | 1.49097 | .69631 | 1.43614 | .72255 | 1.38399 | 9 |
| 52 | .64610 | 1.54774 | .67113 | 1.49003 | .69675 | 1.43525 | .72299 | 1.38314 | 8 |
| 53 | .64652 | 1.54675 | .67155 | 1.48909 | .69718 | 1.43436 | .72344 | 1.38229 | 7 |
| 54 | .64693 | 1.54576 | .67197 | 1.48816 | .69761 | 1.43347 | .72388 | 1.38145 | 6 |
| 55 | .64734 | 1.54478 | .67239 | 1.48722 | .69804 | 1.43258 | .72432 | 1.38060 | 5 |
| 56 | .64775 | 1.54379 | .67282 | 1.48629 | .69874 | 1.43169 | .72477 | 1.37976 | 4 |
| 57 | .64817 | 1.54281 | .67324 | 1.48536 | .69891 | 1.43080 | .72521 | 1.37891 | 3 |
| 58 | .64858 | 1.54183 | .67366 | 1.48442 | .69934 | 1.42992 | .72565 | 1.37807 | 2 |
| 59 | .64899 | 1.54085 | .67409 | 1.48349 | .69977 | 1.42903 | .72610 | 1.37722 | 1 |
| 60 | .64941 | 1.53986 | .67451 | 1.48256 | .70021 | 1.42815 | .72654 | 1.37638 | 0 |
| M. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | M. |
| | 57° | | 56° | | °55 | | 54° | | |

| M. | 36° Tang. | 36° Cotang. | 37° Tang. | 37° Cotang. | 38° Tang. | 38° Cotang. | 39° Tang. | 39° Cotang. | M. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | .72654 | 1.37638 | .75355 | 1.32704 | .78129 | 1.27994 | .80978 | 1.23490 | 60 |
| 1 | .72699 | 1.37554 | .75401 | 1.32624 | .78175 | 1.27917 | .81027 | 1.23416 | 59 |
| 2 | .72743 | 1.37470 | .75447 | 1.32544 | .78222 | 1.27841 | .81075 | 1.23343 | 58 |
| 3 | .72788 | 1.37386 | .75492 | 1.32464 | .78269 | 1.27764 | .81123 | 1.23270 | 57 |
| 4 | .72832 | 1.37302 | .75538 | 1.32384 | .78316 | 1.27688 | .81171 | 1.23196 | 56 |
| 5 | .72877 | 1.37218 | .75584 | 1.32304 | .78363 | 1.27611 | .81220 | 1.23123 | 55 |
| 6 | .72921 | 1.37134 | .75629 | 1.32224 | .78410 | 1.27535 | .81268 | 1.23050 | 54 |
| 7 | .72966 | 1.37050 | .75675 | 1.32144 | .78457 | 1.27458 | .81316 | 1.22977 | 53 |
| 8 | .73010 | 1.36967 | .75721 | 1.32064 | .78504 | 1.27382 | .81364 | 1.22904 | 52 |
| 9 | .73055 | 1.36883 | .75767 | 1.31984 | .78551 | 1.27306 | .81413 | 1.22831 | 51 |
| 10 | .73100 | 1.36800 | .75812 | 1.31904 | .78598 | 1.27230 | .81461 | 1.22758 | 50 |
| 11 | .73144 | 1.36716 | .75858 | 1.31825 | .78645 | 1.27153 | .81510 | 1.22685 | 49 |
| 12 | .73189 | 1.36633 | .75904 | 1.31745 | .78692 | 1.27077 | .81558 | 1.22612 | 48 |
| 13 | .73234 | 1.36549 | .75950 | 1.31666 | .78739 | 1.27001 | .81606 | 1.22539 | 47 |
| 14 | .73278 | 1.36466 | .75996 | 1.31586 | .78786 | 1.26925 | .81655 | 1.22467 | 46 |
| 15 | .73323 | 1.36383 | .76042 | 1.31507 | .78834 | 1.26849 | .81703 | 1.22394 | 45 |
| 16 | .73368 | 1.36300 | .76088 | 1.31427 | .78881 | 1.26774 | .81752 | 1.22321 | 44 |
| 17 | .73413 | 1.36217 | .76134 | 1.31348 | .78928 | 1.26698 | .81800 | 1.22249 | 43 |
| 18 | .73457 | 1.36134 | .76180 | 1.31269 | .78975 | 1.26622 | .81849 | 1.22176 | 42 |
| 19 | .73503 | 1.36051 | .76226 | 1.31190 | .79022 | 1.26546 | .81898 | 1.22104 | 41 |
| 20 | .73547 | 1.35968 | .76272 | 1.31110 | .79070 | 1.26471 | .81946 | 1.22031 | 40 |
| 21 | .73592 | 1.35885 | .76318 | 1.31031 | .79117 | 1.26395 | .81995 | 1.21959 | 39 |
| 22 | .73637 | 1.35802 | .76364 | 1.30952 | .79164 | 1.26319 | .82044 | 1.21886 | 38 |
| 23 | .73681 | 1.35719 | .76410 | 1.30873 | .79212 | 1.26244 | .82092 | 1.21814 | 37 |
| 24 | .73726 | 1.35637 | .76456 | 1.30795 | .79259 | 1.26169 | .82141 | 1.21742 | 36 |
| 25 | .73771 | 1.35554 | .76502 | 1.30716 | .79306 | 1.26093 | .82190 | 1.21670 | 35 |
| 26 | .73816 | 1.35472 | .76548 | 1.30637 | .79354 | 1.26018 | .82238 | 1.21598 | 34 |
| 27 | .73861 | 1.35389 | .76594 | 1.30558 | .79401 | 1.25943 | .82287 | 1.21526 | 33 |
| 28 | .73906 | 1.35307 | .76640 | 1.30480 | .79449 | 1.25867 | .82336 | 1.21454 | 32 |
| 29 | .73951 | 1.35224 | .76686 | 1.30401 | .79496 | 1.25792 | .82385 | 1.21382 | 31 |
| 30 | .73996 | 1.35142 | .76733 | 1.30323 | .79544 | 1.25717 | .82434 | 1.21310 | 30 |
| 31 | .74041 | 1.35060 | .76779 | 1.30244 | .79591 | 1.25642 | .82483 | 1.21238 | 29 |
| 32 | .74086 | 1.34978 | .76825 | 1.30166 | .79639 | 1.25567 | .82531 | 1.21166 | 28 |
| 33 | .74131 | 1.34896 | .76871 | 1.30087 | .79686 | 1.25492 | .82580 | 1.21094 | 27 |
| 34 | .74176 | 1.34814 | .76918 | 1.30009 | .79734 | 1.25417 | .82629 | 1.21023 | 26 |
| 35 | .74221 | 1.34732 | .76964 | 1.29931 | .79781 | 1.25343 | .82678 | 1.20951 | 25 |
| 36 | .74267 | 1.34650 | .77010 | 1.29853 | .79829 | 1.25268 | .82727 | 1.20879 | 24 |
| 37 | .74312 | 1.34568 | .77057 | 1.29775 | .79877 | 1.25193 | .82776 | 1.20808 | 23 |
| 38 | .74357 | 1.34487 | .77103 | 1.29696 | .79924 | 1.25118 | .82825 | 1.20736 | 22 |
| 39 | .74402 | 1.34405 | .77149 | 1.29618 | .79972 | 1.25044 | .82874 | 1.20665 | 21 |
| 40 | .74447 | 1.34323 | .77196 | 1.29541 | .80020 | 1.24969 | .82923 | 1.20593 | 20 |
| 41 | .74492 | 1.34242 | .77242 | 1.29463 | .80067 | 1.24895 | .82972 | 1.20522 | 19 |
| 42 | .74538 | 1.34160 | .77289 | 1.29385 | .80115 | 1.24820 | .83022 | 1.20451 | 18 |
| 43 | .74583 | 1.34079 | .77335 | 1.29307 | .80163 | 1.24746 | .83022 | 1.20379 | 17 |
| 44 | .74628 | 1.33998 | .77382 | 1.29229 | .80211 | 1.24672 | .83120 | 1.20308 | 16 |
| 45 | .74674 | 1.33916 | .77428 | 1.29152 | .80258 | 1.24597 | .83169 | 1.20237 | 15 |
| 46 | .74719 | 1.33835 | .77475 | 1.29074 | .80306 | 1.24523 | .83218 | 1.20166 | 14 |
| 47 | .74764 | 1.33754 | .77521 | 1.28997 | .80354 | 1.24449 | .83268 | 1.20095 | 13 |
| 48 | .74810 | 1.33673 | .77568 | 1.28919 | .80402 | 1.24375 | .83317 | 1.20024 | 12 |
| 49 | .74855 | 1.33592 | .77615 | 1.28842 | .80450 | 1.24301 | .83366 | 1.19953 | 11 |
| 50 | .74900 | 1.33511 | .77661 | 1.28764 | .80498 | 1.24227 | .83415 | 1.19882 | 10 |
| 51 | .74946 | 1.33430 | .77708 | 1.28687 | .80546 | 1.24153 | .83465 | 1.19811 | 9 |
| 52 | .74991 | 1.33349 | .77754 | 1.28610 | .80594 | 1.24079 | .83514 | 1.19740 | 8 |
| 53 | .75037 | 1.33268 | .77801 | 1.28533 | .80642 | 1.24005 | .83564 | 1.19669 | 7 |
| 54 | .75082 | 1.33187 | .77848 | 1.28456 | .80690 | 1.23931 | .83613 | 1.19599 | 6 |
| 55 | .75128 | 1.33107 | .77895 | 1.28379 | .80738 | 1.23858 | .83662 | 1.19528 | 5 |
| 56 | .75173 | 1.33026 | .77941 | 1.28302 | .80786 | 1.23784 | .83712 | 1.19457 | 4 |
| 57 | .75219 | 1.32946 | .77988 | 1.28225 | .80834 | 1.23710 | .83761 | 1.19387 | 3 |
| 58 | .75264 | 1.32865 | .78035 | 1.28148 | .80882 | 1.23637 | .83811 | 1.19316 | 2 |
| 59 | .75310 | 1.32785 | .78082 | 1.28071 | .80930 | 1.23563 | .83860 | 1.19246 | 1 |
| 60 | .75355 | 1.32704 | .78129 | 1.27994 | .80978 | 1.23490 | .83910 | 1.19175 | 0 |
| M. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | M. |
| | 53° | | 52° | | 51° | | 50° | | |

| M. | 40° Tang. | 40° Cotang. | 41° Tang. | 41° Cotang. | 42° Tang. | 42° Cotang. | 43° Tang. | 43° Cotang. | M. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | .83910 | 1.19115 | .86929 | 1.15037 | .90040 | 1.11061 | .93252 | 1.07237 | 60 |
| 1 | .83960 | 1.19105 | .86980 | 1.14969 | .90093 | 1.10996 | .93306 | 1.07174 | 59 |
| 2 | .84009 | 1.19035 | .87031 | 1.14902 | .90146 | 1.10931 | .93360 | 1.07112 | 58 |
| 3 | .84059 | 1.18964 | .87082 | 1.14834 | .90199 | 1.10867 | .93415 | 1.07049 | 57 |
| 4 | .84108 | 1.18894 | .87133 | 1.14767 | .90251 | 1.10802 | .93469 | 1.06987 | 56 |
| 5 | .84158 | 1.18824 | .87184 | 1.14699 | .90304 | 1.10737 | .93524 | 1.06925 | 55 |
| 6 | .84208 | 1.18754 | .87236 | 1.14632 | .90357 | 1.10672 | .93578 | 1.06862 | 54 |
| 7 | .84258 | 1.18684 | .87287 | 1.14565 | .90410 | 1.10607 | .93633 | 1.06800 | 53 |
| 8 | .84307 | 1.18614 | .87338 | 1.14498 | .90463 | 1.10543 | .93688 | 1.06738 | 52 |
| 9 | .84357 | 1.18544 | .87389 | 1.14430 | .90516 | 1.10478 | .93742 | 1.06676 | 51 |
| 10 | .84407 | 1.18474 | .87441 | 1.14363 | .90569 | 1.10414 | .93797 | 1.06613 | 50 |
| 11 | .84457 | 1.18404 | .87492 | 1.14296 | .90621 | 1.10349 | .93852 | 1.06551 | 49 |
| 12 | .84507 | 1.18334 | .87543 | 1.14229 | .90674 | 1.10285 | .93906 | 1.06489 | 48 |
| 13 | .84556 | 1.18264 | .87595 | 1.14162 | .90727 | 1.10220 | .93961 | 1.06427 | 47 |
| 14 | .84606 | 1.18194 | .87646 | 1.14095 | .90781 | 1.10156 | .94016 | 1.06365 | 46 |
| 15 | .84656 | 1.18125 | .87698 | 1.14028 | .90834 | 1.10091 | .74071 | 1.06303 | 45 |
| 16 | .84706 | 1.18055 | .87749 | 1.13961 | .90887 | 1.10027 | .94125 | 1.06241 | 44 |
| 17 | .84756 | 1.17986 | .87801 | 1.13894 | .90940 | 1.09963 | .94180 | 1.06179 | 43 |
| 18 | .84806 | 1.17916 | .87852 | 1.13828 | .90993 | 1.09899 | .94235 | 1.06117 | 42 |
| 19 | .84856 | 1.17846 | .87904 | 1.13761 | .91046 | 1.09834 | .94290 | 1.06056 | 41 |
| 20 | .84906 | 1.17777 | .87955 | 1.13694 | .91099 | 1.09770 | .94345 | 1.05994 | 40 |
| 21 | .84956 | 1.17708 | .88007 | 1.13627 | .91153 | 1.09706 | .94400 | 1.05932 | 39 |
| 22 | .85006 | 1.17638 | .88059 | 1.13561 | .91206 | 1.09642 | .94455 | 1.05870 | 38 |
| 23 | .85057 | 1.17569 | .88110 | 1.13494 | .91259 | 1.09578 | .94510 | 1.05809 | 37 |
| 24 | .85107 | 1.17500 | .88162 | 1.13428 | .91313 | 1.09514 | .94565 | 1.05747 | 36 |
| 25 | .85157 | 1.17430 | .88214 | 1.13361 | .91366 | 1.09450 | .94620 | 1.05685 | 35 |
| 26 | .85207 | 1.17361 | .88265 | 1.13295 | .91419 | 1.09386 | .94676 | 1.05624 | 34 |
| 27 | .85257 | 1.17292 | .88317 | 1.13228 | .91473 | 1.09322 | .94731 | 1.05562 | 33 |
| 28 | .85308 | 1.17223 | .88369 | 1.13162 | .91526 | 1.09258 | .94786 | 1.05501 | 32 |
| 29 | .85358 | 1.17154 | .88421 | 1.13096 | .91580 | 1.09195 | .94841 | 1.05439 | 31 |
| 30 | .85408 | 1.17085 | .88473 | 1.13029 | .91633 | 1.09131 | .94896 | 1.05378 | 30 |
| 31 | .85458 | 1.17016 | .88524 | 1.12963 | .91687 | 1.09067 | .94952 | 1.05317 | 29 |
| 32 | .85509 | 1.16947 | .88576 | 1.12897 | .91740 | 1.09003 | .95007 | 1.05255 | 28 |
| 33 | .85559 | 1.16878 | .88628 | 1.12831 | .91794 | 1.08940 | .95062 | 1.05194 | 27 |
| 34 | .85609 | 1.16809 | .88680 | 1.12765 | .91847 | 1.08876 | .95118 | 1.05133 | 26 |
| 35 | .85660 | 1.16741 | .88732 | 1.12699 | .91901 | 1.08813 | .95173 | 1.05072 | 25 |
| 36 | .85710 | 1.16672 | .88784 | 1.12633 | .91955 | 1.08749 | .95229 | 1.05010 | 24 |
| 37 | .85761 | 1.16603 | .88836 | 1.12567 | .92008 | 1.08686 | .95284 | 1.04949 | 23 |
| 38 | .85811 | 1.16535 | .88888 | 1.12501 | .92062 | 1.08622 | .95340 | 1.04888 | 22 |
| 39 | .85862 | 1.16466 | .88940 | 1.12435 | .92116 | 1.08559 | .95395 | 1.04827 | 21 |
| 40 | .85912 | 1.16398 | .88992 | 1.12369 | .92170 | 1.08496 | .95451 | 1.04766 | 20 |
| 41 | .85963 | 1.16329 | .89045 | 1.12303 | .92224 | 1.08432 | .95506 | 1.04705 | 19 |
| 42 | .86014 | 1.16261 | .89097 | 1.12238 | .92277 | 1.08369 | .95562 | 1.04644 | 18 |
| 43 | .86064 | 1.16192 | .89149 | 1.12172 | .92331 | 1.08306 | .95618 | 1.04583 | 17 |
| 44 | .86115 | 1.16124 | .89201 | 1.12106 | .92385 | 1.08243 | .95673 | 1.04522 | 16 |
| 45 | .86166 | 1.16056 | .89253 | 1.12041 | .92439 | 1.08179 | .95729 | 1.04461 | 15 |
| 46 | .86216 | 1.15987 | .89306 | 1.11975 | .92493 | 1.08116 | .95785 | 1.04401 | 14 |
| 47 | .86267 | 1.15919 | .89358 | 1.11909 | .92547 | 1.08053 | .95841 | 1.04340 | 13 |
| 48 | .86318 | 1.15851 | .89410 | 1.11844 | .92601 | 1.07990 | .95897 | 1.04279 | 12 |
| 49 | .86368 | 1.15783 | .89463 | 1.11778 | .92655 | 1.07927 | .95952 | 1.04218 | 11 |
| 50 | .86419 | 1.15715 | .89515 | 1.11713 | .92709 | 1.07864 | .96008 | 1.04158 | 10 |
| 51 | .86470 | 1.15647 | .89567 | 1.11648 | .92763 | 1.07801 | .96064 | 1.04097 | 9 |
| 52 | .86521 | 1.15579 | .89620 | 1.11582 | .92817 | 1.07738 | .96120 | 1.04036 | 8 |
| 53 | .86572 | 1.15511 | .89672 | 1.11517 | .92872 | 1.07676 | .96176 | 1.03976 | 7 |
| 54 | .86623 | 1.15443 | .89725 | 1.11452 | .92926 | 1.07613 | .96232 | 1.03915 | 6 |
| 55 | .86674 | 1.15375 | .89777 | 1.11387 | .92980 | 1.07550 | .96288 | 1.03855 | 5 |
| 56 | .86725 | 1.15308 | .89830 | 1.11321 | .93034 | 1.07487 | .96344 | 1.03794 | 4 |
| 57 | .86776 | 1.15240 | .89883 | 1.11256 | .93088 | 1.07425 | .96400 | 1.03734 | 3 |
| 58 | .86827 | 1.15172 | .89935 | 1.11191 | .93143 | 1.07362 | .96457 | 1.03674 | 2 |
| 59 | .86878 | 1.15104 | .89988 | 1.11126 | .93197 | 1.07299 | .96513 | 1.03613 | 1 |
| 60 | .86929 | 1.15037 | .90040 | 1.11061 | .93252 | 1.07237 | .96569 | 1.03553 | 0 |
| M. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | Cotang. | Tang. | M. |
| | 49° | | 48° | | 47° | | 46° | | |

| M. | 44° Tang. | 44° Cotang. | M. | M. | 44° Tang. | 44° Cotang. | M. | M. | 44° Tang. | 44° Cotang. | M. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .96569 | 1.03553 | 60 | 20 | .97700 | 1.02355 | 40 | 40 | .98843 | 1.01170 | 20 |
| 1 | .96625 | 1.03493 | 59 | 21 | .97756 | 1.02295 | 39 | 41 | .08901 | 1.01170 | 19 |
| 2 | .96681 | 1.03433 | 58 | 22 | .97813 | 1.02236 | 38 | 42 | .98958 | 1.01053 | 18 |
| 3 | .96738 | 1.03372 | 57 | 23 | .97870 | 1.02176 | 37 | 43 | .99016 | 1.00994 | 17 |
| 4 | .96794 | 1.03312 | 56 | 24 | .97927 | 1.02117 | 36 | 44 | .99073 | 1.00935 | 16 |
| 5 | .96850 | 1.03252 | 55 | 25 | .97984 | 1.02057 | 35 | 45 | .99131 | 1.00876 | 15 |
| 6 | .96907 | 1.03192 | 54 | 26 | .98041 | 1.01998 | 34 | 46 | .99189 | 1.00818 | 14 |
| 7 | .96963 | 1.03132 | 53 | 27 | .98098 | 1.01939 | 33 | 47 | .99247 | 1.00759 | 13 |
| 8 | .97020 | 1.03072 | 52 | 28 | .98155 | 1.01879 | 32 | 40 | .99304 | 1.00701 | 12 |
| 9 | .97076 | 1.03012 | 51 | 29 | .98213 | 1.01820 | 31 | 49 | .99362 | 1.00642 | 11 |
| 10 | .97133 | 1.02952 | 50 | 30 | .98270 | 1.01761 | 30 | 50 | .99420 | 1.00583 | 10 |
| 11 | .97189 | 1.02892 | 49 | 31 | .98327 | 1.01702 | 29 | 51 | .99478 | 1.00525 | 9 |
| 12 | .97246 | 1.02832 | 48 | 32 | .98384 | 1.01642 | 28 | 52 | .99536 | 1.00467 | 8 |
| 13 | .97302 | 1.02772 | 47 | 33 | .98441 | 1.01583 | 27 | 53 | .99594 | 1.00408 | 7 |
| 14 | .97359 | 1.02713 | 46 | 34 | .98499 | 1.01524 | 26 | 54 | .99652 | 1.00350 | 6 |
| 15 | .97416 | 1.02653 | 45 | 35 | .98556 | 1.01465 | 25 | 55 | .99710 | 1.00291 | 5 |
| 16 | .97472 | 1.02593 | 44 | 36 | .98613 | 1.01406 | 24 | 56 | .99768 | 1.00233 | 4 |
| 17 | .97529 | 1.02533 | 43 | 37 | .98671 | 1.01347 | 23 | 57 | .99826 | 1.00175 | 3 |
| 18 | .97586 | 1.02474 | 42 | 38 | .98728 | 1.01288 | 22 | 58 | .99884 | 1.00116 | 2 |
| 19 | .97643 | 1.02414 | 41 | 39 | .98786 | 1.01229 | 21 | 59 | .99942 | 1.00058 | 1 |
| 20 | .97700 | 1.02355 | 40 | 40 | .98843 | 1.01170 | 20 | 60 | 1.00000 | 1.00000 | 0 |
| M. | Cotang. | Tang. | M. | M. | Cotang. | Tang. | M. | M. | Cotang. | Tang. | M. |
| | 45° | | | | 45° | | | | 45° | | |

## TABLE VII.

# TRAVERSE TABLE.

| Course | Dist. 1. | | Dist. 2. | | Dist. 3. | | Dist. 4. | | Dist. 5. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | |
| ° ′ | | | | | | | | | | | ° |
| 0 15 | 1.0000 | 0.0044 | 2.0000 | 0.0087 | 3 0000 | 0.0131 | 4.0000 | 0.0175 | 5.0000 | 0.0218 | 89 45 |
| 30 | 0000 | 0087 | 1.9999 | 0175 | 2.9999 | 0262 | 3.9998 | 0349 | 4.9998 | 0436 | 30 |
| 45 | 0.9999 | 0131 | 9998 | 0262 | 9997 | 0393 | 9997 | 0524 | 9996 | 0654 | 15 |
| 1 0 | 9998 | 0175 | 9997 | 0349 | 9995 | 0524 | 9994 | 0698 | 9992 | 0873 | 89 0 |
| 15 | 9998 | 0218 | 9995 | 0436 | 9993 | 0654 | 9990 | 0873 | 9988 | 1091 | 45 |
| 30 | 9997 | 0262 | 9993 | 0524 | 9990 | 0785 | 9986 | 1047 | 9983 | 1309 | 30 |
| 45 | 9995 | 0305 | 9991 | 0611 | 9986 | 0916 | 9981 | 1222 | 9977 | 1527 | 15 |
| 2 0 | 9994 | 0349 | 9988 | 0698 | 9982 | 1047 | 9976 | 1396 | 9970 | 1745 | 88 0 |
| 15 | 9992 | 0393 | 9985 | 0785 | 9977 | 1178 | 9969 | 1570 | 9961 | 1963 | 45 |
| 30 | 9990 | 0436 | 9981 | 0872 | 9971 | 1309 | 9962 | 1745 | 9952 | 2181 | 30 |
| 45 | 0 9988 | 0.0480 | 1 9977 | 0.0960 | 2.9965 | 0.1439 | 3.9954 | 0.1919 | 4.9942 | 0.2399 | 15 |
| 3 0 | 9986 | 0523 | 9973 | 1047 | 9959 | 1570 | 9945 | 2093 | 9931 | 2617 | 87 0 |
| 15 | 9984 | 0567 | 9968 | 1134 | 9952 | 1701 | 9936 | 2268 | 9920 | 2835 | 45 |
| 30 | 9981 | 0610 | 9963 | 1221 | 9944 | 1831 | 9925 | 2442 | 9907 | 3052 | 30 |
| 45 | 9979 | 0654 | 9957 | 1308 | 9936 | 1962 | 9914 | 2616 | 9893 | 3270 | 15 |
| 4 0 | 9976 | 0698 | 9951 | 1395 | 9927 | 2093 | 9903 | 2790 | 9878 | 3488 | 86 0 |
| 15 | 9973 | 0741 | 9945 | 1482 | 9918 | 2223 | 9890 | 2964 | 9863 | 3705 | 45 |
| 30 | 9969 | 0785 | 9938 | 1569 | 9908 | 2354 | 9877 | 3138 | 9846 | 3923 | 30 |
| 45 | 9966 | 0828 | 9931 | 1656 | 9897 | 2484 | 9863 | 3312 | 9828 | 4140 | 15 |
| 5 0 | 9962 | 0872 | 9924 | 1743 | 9886 | 2615 | 9848 | 3486 | 9810 | 4358 | 85 0 |
| 15 | 0.9958 | 0.0915 | 1.9916 | 0.1830 | 2.9874 | 0.2745 | 3.9832 | 0.3660 | 4.9790 | 0.4575 | 45 |
| 30 | 9954 | 0958 | 9908 | 1917 | 9862 | 2875 | 9816 | 3834 | 9770 | 4792 | 30 |
| 45 | 9950 | 1002 | 9899 | 2004 | 9849 | 3006 | 9799 | 4008 | 9748 | 5009 | 15 |
| 6 0 | 9945 | 1045 | 9890 | 2091 | 9836 | 3136 | 9781 | 4181 | 9726 | 5226 | 84 0 |
| 15 | 9941 | 1089 | 9881 | 2177 | 9822 | 3266 | 9762 | 4355 | 9703 | 5443 | 45 |
| 30 | 9936 | 1132 | 9871 | 2264 | 9807 | 3396 | 9743 | 4528 | 9679 | 5660 | 30 |
| 45 | 9931 | 1175 | 9861 | 2351 | 9792 | 3526 | 9723 | 4701 | 9653 | 5877 | 15 |
| 7 0 | 9925 | 1219 | 9851 | 2437 | 9776 | 3656 | 9702 | 4873 | 9627 | 6093 | 83 0 |
| 15 | 9920 | 1262 | 9840 | 2524 | 9760 | 3786 | 9680 | 5048 | 9600 | 6310 | 45 |
| 30 | 9914 | 1305 | 9829 | 2611 | 9743 | 3916 | 9658 | 5221 | 9572 | 6526 | 30 |
| 45 | 0.9909 | 0.1349 | 1.9817 | 0.2697 | 2.9726 | 0.4046 | 3.9635 | 0.5394 | 4.9543 | 0.6743 | 15 |
| 8 0 | 9903 | 1392 | 9805 | 2783 | 9708 | 4175 | 9611 | 5567 | 9513 | 6959 | 82 0 |
| 15 | 9897 | 1435 | 9793 | 2870 | 9690 | 4305 | 9586 | 5740 | 9483 | 7175 | 45 |
| 30 | 9890 | 1478 | 9780 | 2956 | 9670 | 4434 | 9561 | 5912 | 9451 | 7390 | 30 |
| 45 | 9884 | 1521 | 9767 | 3042 | 9651 | 4564 | 9534 | 6085 | 9418 | 7606 | 15 |
| 9 0 | 9877 | 1564 | 9754 | 3129 | 9631 | 4693 | 9508 | 6257 | 9384 | 7822 | 81 0 |
| 15 | 9870 | 1607 | 9740 | 3215 | 9610 | 4822 | 9480 | 6429 | 9350 | 8037 | 45 |
| 30 | 9863 | 1650 | 9726 | 3301 | 9589 | 4951 | 9451 | 6602 | 9314 | 8252 | 30 |
| 45 | 9856 | 1693 | 9711 | 3387 | 9567 | 5080 | 9422 | 6774 | 9278 | 8467 | 15 |
| 10 0 | 9848 | 1736 | 9696 | 3473 | 9544 | 5209 | 9392 | 6946 | 9240 | 8682 | 80 0 |
| 15 | 0.9840 | 0.1779 | 1.9681 | 0.3559 | 2.9521 | 0.5338 | 3.9362 | 0.7118 | 4.9202 | 0.8897 | 45 |
| 30 | 9833 | 1822 | 9665 | 3645 | 9498 | 5467 | 9330 | 7289 | 9163 | 9112 | 30 |
| 45 | 9825 | 1865 | 9649 | 3730 | 9474 | 5596 | 9298 | 7461 | 9123 | 9326 | 15 |
| 11 0 | 9816 | 1908 | 9633 | 3816 | 9449 | 5724 | 9265 | 7632 | 9081 | 9540 | 79 0 |
| 15 | 9808 | 1951 | 9616 | 3902 | 9424 | 5853 | 9231 | 7804 | 9039 | 9755 | 45 |
| 30 | 9799 | 1994 | 9598 | 3987 | 9398 | 5981 | 9197 | 7975 | 8996 | 9968 | 30 |
| 45 | 9790 | 2036 | 9581 | 4073 | 9371 | 6109 | 9162 | 8146 | 8952 | 1.0182 | 15 |
| 12 0 | 9781 | 2079 | 9563 | 4158 | 9344 | 6237 | 9126 | 8316 | 8907 | 0396 | 78 0 |
| 15 | 9772 | 2122 | 9545 | 4244 | 9317 | 6365 | 9089 | 8487 | 8862 | 0609 | 45 |
| 30 | 9763 | 2164 | 9526 | 4329 | 9289 | 6493 | 9052 | 8658 | 8815 | 0822 | 30 |
| 45 | 0.9753 | 0.2207 | 1.9507 | 0.4414 | 2.9260 | 0.6621 | 3.9014 | 0.8828 | 4.8767 | 1.1035 | 15 |
| 13 0 | 9744 | 2250 | 9487 | 4499 | 9231 | 6749 | 8975 | 8998 | 8719 | 1248 | 77 0 |
| 15 | 9734 | 2292 | 9468 | 4584 | 9201 | 6876 | 8935 | 9168 | 8669 | 1460 | 45 |
| 30 | 9724 | 2334 | 9447 | 4669 | 9171 | 7003 | 8895 | 9338 | 8618 | 1672 | 30 |
| 45 | 9713 | 2377 | 9427 | 4754 | 9140 | 7131 | 8854 | 9507 | 8567 | 1884 | 15 |
| 14 0 | 9703 | 2419 | 9406 | 4838 | 9109 | 7258 | 8812 | 9677 | 8515 | 2096 | 76 0 |
| 15 | 9692 | 2462 | 9385 | 4923 | 9077 | 7385 | 8769 | 9846 | 8462 | 2308 | 45 |
| 30 | 9681 | 2504 | 9363 | 5008 | 9044 | 7511 | 8726 | 1.0015 | 8407 | 2519 | 30 |
| 45 | 9670 | 2546 | 9341 | 5092 | 9011 | 7638 | 8682 | 0184 | 8352 | 2730 | 15 |
| 15 0 | 9659 | 2588 | 9319 | 5176 | 8978 | 7765 | 8637 | 0353 | 8296 | 2941 | 75 0 |
| | Dep. \| Lat. | | Dep. \| Lat. | | Dep. \| Lat. | | Dep. \| Lat. | | Dep. \| Lat. | Course |
| | Dist. 1. | | Dist. 2. | | Dist. 3. | | Dist. 4. | | Dist. 5. | | |

| Course | Dist. 6. | | Dist. 7. | | Dist. 8. | | Dist. 9. | | Dist. 10. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | |
| ° ′ | | | | | | | | | | | ° |
| 0 15 | 5.9999 | 0.0262 | 6.9999 | 0.0305 | 7.9999 | 0.0349 | 8.9999 | 0.0393 | 9.9999 | 0.0436 | 89 45 |
| 30 | 9998 | 0524 | 9997 | 0611 | 9997 | 0698 | 9997 | 0785 | 9996 | 0873 | 30 |
| 45 | 9995 | 0785 | 9994 | 0916 | 9993 | 1047 | 9992 | 1178 | 9991 | 1309 | 15 |
| 1 0 | 9991 | 1047 | 9989 | 1222 | 9988 | 1396 | 9986 | 1571 | 9985 | 1745 | 89 0 |
| 15 | 9986 | 1309 | 9983 | 1527 | 9981 | 1745 | 9979 | 1963 | 9976 | 2181 | 45 |
| 30 | 9979 | 1571 | 9976 | 1832 | 9973 | 2094 | 9969 | 2356 | 9966 | 2618 | 30 |
| 45 | 9972 | 1832 | 9967 | 2138 | 9963 | 2443 | 9958 | 2748 | 9953 | 3054 | 15 |
| 2 0 | 9963 | 2094 | 9957 | 2443 | 9951 | 2792 | 9945 | 3141 | 9939 | 3490 | 88 0 |
| 15 | 9954 | 2356 | 9946 | 2748 | 9938 | 3141 | 9931 | 3533 | 9923 | 3926 | 45 |
| 30 | 9943 | 2617 | 9933 | 3053 | 9924 | 3490 | 9914 | 3926 | 9905 | 4362 | 30 |
| 45 | 5.9931 | 0.2879 | 6.9919 | 0.3358 | 7.9908 | 0.3838 | 8.9896 | 0.4318 | 9.9885 | 0.4798 | 15 |
| 3 0 | 9918 | 3140 | 9904 | 3664 | 9890 | 4187 | 9877 | 4710 | 9863 | 5234 | 87 0 |
| 15 | 9904 | 3402 | 9887 | 3968 | 9871 | 4535 | 9855 | 5102 | 98 9 | 5669 | 45 |
| 30 | 9888 | 3663 | 9869 | 4273 | 9851 | 4884 | 9832 | 5494 | 9813 | 6105 | 30 |
| 45 | 9872 | 3924 | 9850 | 4578 | 9829 | 5232 | 9807 | 5886 | 9786 | 6540 | 15 |
| 4 0 | 9854 | 4185 | 9829 | 4883 | 9805 | 5581 | 9781 | 6278 | 9756 | 6976 | 86 0 |
| 15 | 9835 | 4447 | 9808 | 5188 | 9780 | 5929 | 9753 | 6670 | 9725 | 7411 | 45 |
| 30 | 9815 | 4708 | 9784 | 5492 | 9753 | 6277 | 9723 | 7061 | 9692 | 7846 | 30 |
| 45 | 9794 | 4968 | 9760 | 5797 | 9725 | 6625 | 9691 | 7453 | 9657 | 8281 | 15 |
| 5 0 | 9772 | 5229 | 9734 | 6101 | 9696 | 6972 | 9658 | 7844 | 9619 | 8716 | 85 0 |
| 15 | 5.9748 | 0.5490 | 6.9706 | 0.6405 | 7.9664 | 0.7320 | 8.9622 | 0.8235 | 9.9580 | 0.9150 | 45 |
| 30 | 9724 | 5751 | 9678 | 6709 | 9632 | 7668 | 9586 | 8626 | 9540 | 9585 | 30 |
| 45 | 9698 | 6011 | 9648 | 7013 | 9597 | 8015 | 9547 | 9017 | 9497 | 1.0019 | 15 |
| 6 0 | 9671 | 6272 | 9617 | 7317 | 9562 | 8362 | 9507 | 9408 | 9452 | 0453 | 84 0 |
| 15 | 9643 | 6532 | 9584 | 7621 | 9525 | 8709 | 9465 | 9798 | 9406 | 0887 | 45 |
| 30 | 9614 | 6792 | 9550 | 7924 | 9486 | 9056 | 9421 | 1.0188 | 9357 | 1320 | 30 |
| 45 | 9584 | 7052 | 9515 | 8228 | 9445 | 9403 | 9376 | 0578 | 9307 | 1754 | 15 |
| 7 0 | 9553 | 7312 | 9478 | 8531 | 9404 | 9750 | 9329 | 0968 | 9255 | 2187 | 83 0 |
| 15 | 9520 | 7572 | 9440 | 8834 | 9360 | 1.0096 | 9280 | 1358 | 9200 | 2620 | 45 |
| 30 | 9487 | 7832 | 9401 | 9137 | 9316 | 0442 | 9230 | 1747 | 9144 | 3053 | 30 |
| 45 | 5.9452 | 0.8091 | 6.9361 | 0.9440 | 7.9269 | 1.0788 | 8.9178 | 1.2137 | 9.9087 | 1.3485 | 15 |
| 8 0 | 9416 | 8350 | 9319 | 9742 | 9221 | 1134 | 9124 | 2526 | 9027 | 3917 | 82 0 |
| 15 | 9379 | 8610 | 9276 | 1.0044 | 9172 | 1479 | 9069 | 2914 | 8965 | 4349 | 45 |
| 30 | 9341 | 8869 | 9231 | 0347 | 9121 | 1825 | 9011 | 3303 | 8902 | 4781 | 30 |
| 45 | 9302 | 9127 | 9185 | 0649 | 9069 | 2170 | 8953 | 3691 | 8836 | 5212 | 15 |
| 9 0 | 9261 | 9386 | 9138 | 0950 | 9015 | 2515 | 8892 | 4079 | 8769 | 5643 | 81 0 |
| 15 | 9220 | 9645 | 9090 | 1252 | 8960 | 2859 | 8830 | 4467 | 8700 | 6074 | 45 |
| 30 | 9177 | 9903 | 9040 | 1553 | 8903 | 3204 | 8766 | 4854 | 8629 | 6505 | 30 |
| 45 | 9133 | 1.0161 | 8989 | 1854 | 8844 | 3548 | 8700 | 5241 | 8556 | 6935 | 15 |
| 10 0 | 9088 | 0419 | 8937 | 2155 | 8785 | 3892 | 8633 | 5628 | 8481 | 7365 | 80 0 |
| 15 | 5.9042 | 1.0677 | 6.8883 | 1.2456 | 7.8723 | 1.4235 | 8.8564 | 1.6015 | 9.8404 | 1.7794 | 45 |
| 30 | 8995 | 0934 | 8828 | 2756 | 8660 | 4579 | 8493 | 6401 | 8325 | 8224 | 30 |
| 45 | 8947 | 1191 | 8772 | 3057 | 8596 | 4922 | 8421 | 6787 | 8245 | 8652 | 15 |
| 11 0 | 8898 | 1449 | 8714 | 3357 | 8530 | 5265 | 8346 | 7173 | 8163 | 9081 | 79 0 |
| 15 | 8847 | 1705 | 8655 | 3656 | 8463 | 5607 | 8271 | 7558 | 8079 | 9509 | 45 |
| 30 | 8795 | 1962 | 8595 | 3956 | 8394 | 5949 | 8193 | 7943 | 7992 | 9937 | 30 |
| 45 | 8743 | 2219 | 8533 | 4255 | 8324 | 6291 | 8114 | 8328 | 7905 | 2.0364 | 15 |
| 12 0 | 8689 | 2475 | 8470 | 4554 | 8252 | 6633 | 8033 | 8712 | 7815 | 0791 | 78 0 |
| 15 | 8634 | 2731 | 8406 | 4852 | 8178 | 6974 | 795 | 9096 | 7723 | 1218 | 45 |
| 30 | 8578 | 2986 | 8341 | 5151 | 8104 | 7315 | 7867 | 9480 | 7630 | 1644 | 30 |
| 45 | 5.8521 | 1.3242 | 6.8274 | 1.5449 | 7.8027 | 1.7656 | 8.7781 | 1.9863 | 9.7534 | 2.2070 | 15 |
| 13 0 | 8462 | 3497 | 8206 | 5747 | 7950 | 7996 | 7698 | 2 0246 | 7437 | 2495 | 77 0 |
| 15 | 8403 | 3752 | 8137 | 6044 | 7870 | 8336 | 7604 | 0628 | 7338 | 2920 | 45 |
| 30 | 8342 | 4007 | 8066 | 6341 | 7790 | 8676 | 7513 | 1010 | 7237 | 3345 | 30 |
| 45 | 8281 | 4261 | 7994 | 6638 | 7707 | 9015 | 7421 | 1392 | 7134 | 3769 | 15 |
| 14 0 | 8218 | 4515 | 7921 | 6935 | 7624 | 9354 | 7327 | 1773 | 7030 | 4192 | 76 0 |
| 15 | 8154 | 4769 | 7846 | 7231 | 7538 | 9692 | 7231 | 2154 | 6923 | 4615 | 45 |
| 30 | 8089 | 5023 | 7770 | 7527 | 7452 | 2.0030 | 7133 | 2534 | 6815 | 5038 | 30 |
| 45 | 8023 | 5276 | 7693 | 7822 | 7364 | 0368 | 7034 | 2914 | 6705 | 5460 | 15 |
| 15 0 | 7956 | 5529 | 7615 | 8117 | 7274 | 0706 | 6933 | 3294 | 6593 | 5882 | 75 0 |
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| 15 15 | 0.9648 | 0.2630 | 1.9296 | 0.5261 | 2.8944 | 0.7891 | 3.8591 | 1.0521 | 4.8239 | 1.3152 | 74 45 |
| 30 | 9636 | 2672 | 9273 | 5345 | 8909 | 8017 | 8545 | 0690 | 8182 | 3362 | 30 |
| 45 | 9625 | 2714 | 9249 | 5429 | 8874 | 8143 | 8498 | 0858 | 8123 | 3572 | 15 |
| 16 0 | 9613 | 2756 | 9225 | 5513 | 8838 | 8269 | 8450 | 1025 | 8063 | 3782 | 74 0 |
| 15 | 9600 | 2798 | 9201 | 5597 | 8801 | 8395 | 8402 | 1193 | 8002 | 3991 | 45 |
| 30 | 9588 | 2840 | 9176 | 5680 | 8765 | 8520 | 8353 | 1361 | 7941 | 4201 | 30 |
| 45 | 9576 | 2882 | 9151 | 5764 | 8727 | 8646 | 8303 | 1528 | 7879 | 4410 | 15 |
| 17 0 | 9563 | 2924 | 9126 | 5847 | 8689 | 8771 | 8252 | 1695 | 7815 | 4619 | 73 0 |
| 15 | 9550 | 2965 | 9100 | 5931 | 8651 | 8896 | 8201 | 1862 | 7751 | 4827 | 45 |
| 30 | 9537 | 3007 | 9074 | 6014 | 8612 | 9021 | 8149 | 2028 | 7686 | 5035 | 30 |
| 45 | 0.9524 | 0.3049 | 1.9048 | 0.6097 | 2.8572 | 0.9146 | 3.8096 | 1.2195 | 4.7620 | 1.5243 | 15 |
| 18 0 | 9511 | 3090 | 9021 | 6180 | 8532 | 9271 | 8042 | 2361 | 7553 | 5451 | 72 0 |
| 15 | 9497 | 3132 | 8994 | 6263 | 8491 | 9395 | 7988 | 2527 | 7485 | 5658 | 45 |
| 30 | 9483 | 3173 | 8966 | 6346 | 8450 | 9519 | 7933 | 2692 | 7416 | 5865 | 30 |
| 45 | 9469 | 3214 | 8939 | 6429 | 8408 | 9643 | 7877 | 2858 | 7347 | 6072 | 15 |
| 19 0 | 9455 | 3256 | 8910 | 6511 | 8366 | 9767 | 7821 | 3023 | 7276 | 6278 | 71 0 |
| 15 | 9441 | 3297 | 8882 | 6594 | 8323 | 9891 | 7764 | 3188 | 7204 | 6485 | 45 |
| 30 | 9426 | 3338 | 8853 | 6676 | 8279 | 1.0014 | 7706 | 3352 | 7132 | 6690 | 30 |
| 45 | 9412 | 3379 | 8824 | 6758 | 8235 | 0138 | 7647 | 3517 | 7059 | 6896 | 15 |
| 20 0 | 9397 | 3420 | 8794 | 6840 | 8191 | 0261 | 7588 | 3681 | 6985 | 7101 | 70 0 |
| 15 | 0.9382 | 0.3461 | 1.8764 | 0.6922 | 2.8146 | 1.0384 | 3.7528 | 1.2845 | 4.6910 | 1.7306 | 45 |
| 30 | 9367 | 3502 | 8733 | 7004 | 8100 | 0506 | 7467 | 4008 | 6834 | 7510 | 30 |
| 45 | 9351 | 3543 | 8703 | 7086 | 8054 | 0629 | 7405 | 4172 | 6757 | 7715 | 15 |
| 21 0 | 9336 | 3584 | 8672 | 7167 | 8007 | 0751 | 7343 | 4335 | 6679 | 7918 | 69 0 |
| 15 | 9320 | 3624 | 8640 | 7249 | 7960 | 0873 | 7280 | 4498 | 6600 | 8122 | 45 |
| 30 | 9304 | 3665 | 8608 | 7330 | 7913 | 0995 | 7217 | 4660 | 6521 | 8325 | 30 |
| 45 | 9288 | 3706 | 8576 | 7411 | 7864 | 1117 | 7152 | 4822 | 6440 | 8528 | 15 |
| 22 0 | 9272 | 3746 | 8544 | 7492 | 7816 | 1238 | 7087 | 4984 | 6359 | 8730 | 68 0 |
| 15 | 9255 | 3786 | 8511 | 7573 | 7766 | 1359 | 7022 | 5146 | 6277 | 8932 | 45 |
| 30 | 9239 | 3827 | 8478 | 7654 | 7716 | 1481 | 6935 | 5307 | 6194 | 9134 | 30 |
| 45 | 0.9222 | 0.3867 | 1.8444 | 0.7734 | 2.7666 | 1.1601 | 3.6888 | 1.5468 | 4.6110 | 1.9336 | 15 |
| 23 0 | 9205 | 3907 | 8410 | 7815 | 7615 | 1722 | 6820 | 5629 | 6025 | 9537 | 67 0 |
| 15 | 9188 | 3947 | 8376 | 7895 | 7564 | 1842 | 6752 | 5790 | 5940 | 9737 | 45 |
| 30 | 9171 | 3987 | 8341 | 7975 | 7512 | 1962 | 6682 | 5950 | 5853 | 9937 | 30 |
| 45 | 9153 | 4027 | 8306 | 8055 | 7459 | 2082 | 6612 | 6110 | 5766 | 2.0137 | 15 |
| 24 0 | 9135 | 4067 | 8271 | 8135 | 7406 | 2202 | 6542 | 6269 | 5677 | 0337 | 66 0 |
| 15 | 9118 | 4107 | 8235 | 8214 | 7353 | 2322 | 6470 | 6429 | 5588 | 0536 | 45 |
| 30 | 9100 | 4147 | 8199 | 8294 | 7299 | 2441 | 6398 | 6588 | 5498 | 0735 | 30 |
| 45 | 9081 | 4187 | 8163 | 8373 | 7244 | 2560 | 6326 | 6746 | 5407 | 0933 | 15 |
| 25 0 | 9063 | 4226 | 8126 | 8452 | 7189 | 2679 | 6252 | 6905 | 5315 | 1131 | 65 0 |
| 15 | 0.9045 | 0.4266 | 1.8089 | 0.8531 | 2.7134 | 1.2797 | 3.6178 | 1.7063 | 4.5223 | 2.1328 | 45 |
| 30 | 9026 | 4305 | 8052 | 8610 | 7078 | 2915 | 6103 | 7220 | 5129 | 1526 | 30 |
| 45 | 9007 | 4344 | 8014 | 8689 | 7021 | 3033 | 6028 | 7378 | 5035 | 1722 | 15 |
| 26 0 | 8988 | 4384 | 7976 | 8767 | 6964 | 3151 | 5952 | 7535 | 4940 | 1919 | 64 0 |
| 15 | 8969 | 4423 | 7937 | 8846 | 6906 | 3269 | 5875 | 7692 | 4844 | 2114 | 45 |
| 30 | 8949 | 4462 | 7899 | 8924 | 6848 | 3386 | 5797 | 7848 | 4747 | 2310 | 30 |
| 45 | 8930 | 4501 | 7860 | 9002 | 6789 | 3503 | 5719 | 8004 | 4649 | 2505 | 15 |
| 27 0 | 8910 | 4540 | 7820 | 9080 | 6730 | 3620 | 5640 | 8160 | 4550 | 2700 | 63 0 |
| 15 | 8890 | 4579 | 7780 | 9157 | 6671 | 3736 | 5561 | 8315 | 4451 | 2894 | 45 |
| 30 | 8870 | 4617 | 7740 | 9235 | 6610 | 3852 | 5480 | 8470 | 4351 | 3087 | 30 |
| 45 | 0.8850 | 0.4656 | 1.7700 | 0.9312 | 2.6550 | 1.3968 | 3.5400 | 1.8625 | 4.4249 | 2.3281 | 15 |
| 28 0 | 8829 | 4695 | 7659 | 9389 | 6488 | 4084 | 5318 | 8779 | 4147 | 3474 | 62 0 |
| 15 | 8809 | 4733 | 7618 | 9466 | 6427 | 4200 | 5236 | 8933 | 4045 | 3666 | 45 |
| 30 | 8788 | 4772 | 7576 | 9543 | 6365 | 4315 | 5153 | 9086 | 3941 | 3858 | 30 |
| 45 | 8767 | 4810 | 7535 | 9620 | 6302 | 4430 | 5069 | 9240 | 3836 | 4049 | 15 |
| 29 0 | 8746 | 4848 | 7492 | 9696 | 6239 | 4544 | 4985 | 9392 | 3731 | 4240 | 61 0 |
| 15 | 8725 | 4886 | 7450 | 9772 | 6175 | 4659 | 4900 | 9545 | 3625 | 4431 | 45 |
| 30 | 8704 | 4924 | 7407 | 9848 | 6111 | 4773 | 4814 | 9697 | 3518 | 4621 | 30 |
| 45 | 8682 | 4962 | 7364 | 9924 | 6046 | 4886 | 4728 | 9849 | 3410 | 4811 | 15 |
| 30 0 | 8660 | 5000 | 7321 | 1.0000 | 5981 | 5000 | 4641 | 2.0000 | 3301 | 5000 | 60 0 |
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| 15 15 | 5.7887 | 1.5782 | 6.7535 | 1.8412 | 7.7183 | 2.1042 | 8.6831 | 2.3673 | 9.6479 | 2.6303 | 74 45 |
| 30 | 7918 | 6034 | 7454 | 8707 | 7090 | 1379 | 6727 | 4051 | 6363 | 6724 | 30 |
| 45 | 7747 | 6286 | 7372 | 9001 | 6996 | 1715 | 6621 | 4430 | 6246 | 7144 | 15 |
| 16 0 | 7676 | 6538 | 7288 | 9295 | 6901 | 2051 | 6514 | 4807 | 6126 | 7564 | 74 0 |
| 15 | 7603 | 6790 | 7203 | 9588 | 6804 | 2386 | 6404 | 5185 | 6005 | 7983 | 45 |
| 30 | 7529 | 7041 | 7117 | 9881 | 6706 | 2721 | 6294 | 5561 | 5882 | 8402 | 30 |
| 45 | 7454 | 7292 | 7030 | 2.0174 | 6606 | 3056 | 6181 | 5938 | 5757 | 8820 | 15 |
| 17 0 | 7378 | 7542 | 6941 | 0466 | 6504 | 3390 | 6067 | 6313 | 5630 | 9237 | 73 0 |
| 15 | 7301 | 7792 | 6851 | 0758 | 6402 | 3723 | 5952 | 6689 | 5502 | 9654 | 45 |
| 30 | 7223 | 8042 | 6760 | 1049 | 6297 | 4056 | 5835 | 7064 | 5372 | 3.0071 | 30 |
| 45 | 5.7144 | 1.8292 | 6.6668 | 2.1341 | 7.6192 | 2.4389 | 8.5716 | 2.7438 | 9.5240 | 3.0486 | 15 |
| 18 0 | 7063 | 8541 | 6574 | 1631 | 6085 | 4721 | 5595 | 7812 | 5106 | 0902 | 72 0 |
| 15 | 6982 | 8790 | 6479 | 1921 | 5976 | 5053 | 5473 | 8185 | 4970 | 1316 | 45 |
| 30 | 6899 | 9038 | 6383 | 2211 | 5866 | 5384 | 5349 | 8557 | 4832 | 1730 | 30 |
| 45 | 6816 | 9286 | 6285 | 2501 | 5754 | 5715 | 5224 | 8930 | 4693 | 2144 | 15 |
| 19 0 | 6731 | 9534 | 6186 | 2790 | 5641 | 6045 | 5097 | 9301 | 4552 | 2557 | 71 0 |
| 15 | 6645 | 9781 | 6086 | 3078 | 5527 | 6375 | 4968 | 9672 | 4409 | 2969 | 45 |
| 30 | 6558 | 2.0028 | 5985 | 3366 | 5411 | 6705 | 4838 | 3.0043 | 4264 | 3381 | 30 |
| 45 | 6471 | 0275 | 5882 | 3654 | 5294 | 7033 | 4706 | 0413 | 4118 | 3792 | 15 |
| 20 0 | 6382 | 0521 | 5778 | 3941 | 5175 | 7362 | 4572 | 0782 | 3969 | 4202 | 70 0 |
| 15 | 5.6291 | 2.0767 | 6.5673 | 2.4228 | 7.5055 | 2.7689 | 8.4437 | 3.1151 | 9.3819 | 3.4612 | 45 |
| 30 | 6200 | 1012 | 5567 | 4515 | 4934 | 8017 | 4300 | 1519 | 3667 | 5021 | 30 |
| 45 | 6108 | 1257 | 5459 | 4800 | 4811 | 8343 | 4162 | 1886 | 3514 | 5429 | 15 |
| 21 0 | 6015 | 1502 | 5351 | 5086 | 4686 | 8669 | 4022 | 2253 | 3358 | 5837 | 69 0 |
| 15 | 5920 | 1746 | 5241 | 5371 | 4561 | 8995 | 3881 | 2619 | 3201 | 6244 | 45 |
| 30 | 5825 | 1990 | 5129 | 5655 | 4433 | 9320 | 3738 | 2985 | 3042 | 6650 | 30 |
| 45 | 5729 | 2233 | 5017 | 5939 | 4305 | 9645 | 3593 | 3350 | 2881 | 7056 | 15 |
| 22 0 | 5631 | 2476 | 4903 | 6222 | 4175 | 9969 | 3447 | 3715 | 2718 | 7461 | 68 0 |
| 15 | 5532 | 2719 | 4788 | 6505 | 4043 | 3.0292 | 3299 | 4078 | 2554 | 7865 | 45 |
| 30 | 5433 | 2961 | 4672 | 6788 | 3910 | 0615 | 3149 | 4442 | 2388 | 8268 | 30 |
| 45 | 5.5332 | 2.3203 | 6.4554 | 2.7070 | 7.3776 | 3.0937 | 8.2998 | 3.4804 | 9.2220 | 3.8671 | 15 |
| 23 0 | 5230 | 3444 | 4435 | 7351 | 3640 | 1258 | 2845 | 5166 | 2050 | 9073 | 67 0 |
| 15 | 5127 | 3685 | 4315 | 7632 | 3503 | 1580 | 2691 | 5527 | 1879 | 9474 | 45 |
| 30 | 5024 | 3925 | 4194 | 7912 | 3365 | 1900 | 2535 | 5887 | 1706 | 9875 | 30 |
| 45 | 4919 | 4165 | 4072 | 8192 | 3225 | 2220 | 2378 | 6247 | 1531 | 4.0275 | 15 |
| 24 0 | 4813 | 4404 | 3948 | 8472 | 3084 | 2539 | 2219 | 6606 | 1355 | 0674 | 66 0 |
| 15 | 4706 | 4643 | 3823 | 8750 | 2941 | 2858 | 2059 | 6965 | 1176 | 1072 | 45 |
| 30 | 4598 | 4882 | 3697 | 9029 | 2797 | 3175 | 1897 | 7322 | 0996 | 1469 | 30 |
| 45 | 4489 | 5120 | 3570 | 9306 | 2651 | 3493 | 1733 | 7679 | 0814 | 1866 | 15 |
| 25 0 | 4378 | 5357 | 3442 | 9583 | 2505 | 3809 | 1568 | 8036 | 0631 | 2262 | 65 0 |
| 15 | 5.4267 | 2.5594 | 6.3312 | 2.9860 | 7.2356 | 3.4125 | 8.1401 | 3.8391 | 9.0446 | 4.2657 | 45 |
| 30 | 4155 | 5831 | 3181 | 3.0136 | 2207 | 4441 | 123 | 8746 | 0259 | 3051 | 30 |
| 45 | 4042 | 6067 | 3049 | 0411 | 2056 | 4756 | 1063 | 9100 | 0070 | 3445 | 15 |
| 26 0 | 3928 | 6302 | 2916 | 0686 | 1904 | 5070 | 0891 | 9453 | 8.9879 | 3837 | 64 0 |
| 15 | 3812 | 6537 | 2781 | 0960 | 1750 | 5383 | 0719 | 9806 | 9687 | 4229 | 45 |
| 30 | 3696 | 6772 | 2645 | 1234 | 1595 | 5696 | 0 44 | 4.0158 | 9493 | 4620 | 30 |
| 45 | 3579 | 7006 | 2509 | 1507 | 1438 | 6008 | 0368 | 0509 | 9298 | 5010 | 15 |
| 27 0 | 3460 | 7239 | 2370 | 1779 | 1281 | 6319 | 0191 | 0859 | 9101 | 5399 | 63 0 |
| 15 | 3341 | 7472 | 2231 | 2051 | 1121 | 6630 | 0012 | 1209 | 8902 | 5787 | 45 |
| 30 | 3221 | 7705 | 2091 | 2322 | 0961 | 6940 | 7.9831 | 1557 | 8701 | 6175 | 30 |
| 45 | 5.3099 | 2.7937 | 6.1949 | 3.2593 | 7.0799 | 3.7249 | 7.9649 | 4.1905 | 8.8499 | 4.6561 | 15 |
| 28 0 | 2977 | 8168 | 1806 | 2863 | 0636 | 7558 | 9465 | 2252 | 829 | 6947 | 62 0 |
| 15 | 2853 | 8399 | 1662 | 3132 | 0471 | 7866 | 9280 | 2599 | 8 89 | 7332 | 45 |
| 30 | 2729 | 8630 | 1517 | 3401 | 0305 | 8173 | 9094 | 2944 | 7882 | 7716 | 30 |
| 45 | 2604 | 8859 | 1371 | 3669 | 0138 | 8479 | 8905 | 3289 | 7673 | 8099 | 15 |
| 29 0 | 2477 | 9089 | 1223 | 3937 | 6.9970 | 8785 | 8716 | 3633 | 7462 | 8481 | 61 0 |
| 15 | 2350 | 9317 | 1075 | 4203 | 9800 | 9090 | 8525 | 3976 | 7250 | 8862 | 45 |
| 30 | 2221 | 9545 | 0925 | 4470 | 9628 | 9394 | 8332 | 4318 | 7036 | 9242 | 30 |
| 45 | 2092 | 9773 | 0774 | 4735 | 9456 | 9697 | 8138 | 4659 | 6820 | 9622 | 15 |
| 30 0 | 1962 | 3.0000 | 0622 | 5000 | 9282 | 4.0000 | 7942 | 5000 | 6603 | 5.0000 | 60 0 |
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| 30 15 | 0.8638 | 0.5038 | 1.7277 | 1.0075 | 2.5915 | 1.5113 | 3.4553 | 2.0151 | 4.3192 | 2.5189 | 59 45 |
| 30 | 8616 | 5075 | 7233 | 0151 | 5849 | 5226 | 4465 | 0302 | 3081 | 5377 | 30 |
| 45 | 8594 | 5113 | 7188 | 0226 | 5782 | 5339 | 4376 | 0452 | 2970 | 5565 | 15 |
| 31 0 | 8572 | 5150 | 7142 | 0301 | 5715 | 5451 | 4287 | 0602 | 2858 | 5752 | 59 0 |
| 15 | 8549 | 5188 | 7098 | 0375 | 5647 | 5563 | 4196 | 0751 | 2746 | 5939 | 45 |
| 30 | 8526 | 5225 | 7053 | 0450 | 5579 | 5675 | 4106 | 0900 | 2632 | 6125 | 30 |
| 45 | 8504 | 5262 | 7007 | 0524 | 5511 | 5786 | 4014 | 1049 | 2518 | 6311 | 15 |
| 32 0 | 8480 | 5299 | 6961 | 0598 | 5441 | 5898 | 3922 | 1197 | 2402 | 6496 | 58 0 |
| 15 | 8457 | 5336 | 6915 | 0672 | 5372 | 6008 | 3829 | 1345 | 2286 | 6681 | 45 |
| 30 | 8434 | 5373 | 6868 | 0746 | 5302 | 6119 | 3736 | 1492 | 2170 | 6865 | 30 |
| 45 | 0.8410 | 0.5410 | 1.6821 | 1.0819 | 2.5231 | 1.6229 | 3.3642 | 2.1639 | 4.2052 | 2.7049 | 15 |
| 33 0 | 8387 | 5446 | 6773 | 0893 | 5160 | 6339 | 3547 | 1786 | 1934 | 7232 | 57 0 |
| 15 | 8363 | 5483 | 6726 | 0966 | 5089 | 6449 | 3451 | 1932 | 1814 | 7415 | 45 |
| 30 | 8339 | 5519 | 6678 | 1039 | 5017 | 6558 | 3355 | 2077 | 1694 | 7597 | 30 |
| 45 | 8315 | 5556 | 6629 | 1111 | 4944 | 6667 | 3259 | 2223 | 1573 | 7779 | 15 |
| 34 0 | 8290 | 5592 | 6581 | 1184 | 4871 | 6776 | 3162 | 2368 | 1452 | 7960 | 56 0 |
| 15 | 8266 | 5628 | 6532 | 1256 | 4798 | 6884 | 3064 | 2512 | 1329 | 8140 | 45 |
| 30 | 8241 | 5664 | 6483 | 1328 | 4724 | 6992 | 2965 | 2656 | 1206 | 8320 | 30 |
| 45 | 8216 | 5700 | 6433 | 1400 | 4649 | 7100 | 2866 | 2800 | 1082 | 8500 | 15 |
| 35 0 | 8192 | 5736 | 6383 | 1472 | 4575 | 7207 | 2766 | 2943 | 0958 | 8679 | 55 0 |
| 15 | 0.8166 | 0.5771 | 1.6333 | 1.1543 | 2.4499 | 1.7314 | 3.2666 | 2.3086 | 4.0832 | 2.8857 | 45 |
| 30 | 8141 | 5807 | 6282 | 1614 | 4423 | 7421 | 2565 | 3228 | 0706 | 9035 | 30 |
| 45 | 8116 | 5842 | 6231 | 1685 | 4347 | 7527 | 2463 | 3370 | 0579 | 9212 | 15 |
| 36 0 | 8090 | 5878 | 6180 | 1756 | 4271 | 7634 | 2361 | 3511 | 0451 | 9389 | 54 0 |
| 15 | 8064 | 5913 | 6129 | 1826 | 4193 | 7739 | 2258 | 3652 | 0322 | 9565 | 45 |
| 30 | 8039 | 5948 | 6077 | 1896 | 4116 | 7845 | 2154 | 3793 | 0193 | 9741 | 30 |
| 45 | 8013 | 5983 | 6025 | 1966 | 4038 | 7950 | 2050 | 3933 | 0063 | 9916 | 15 |
| 37 0 | 7986 | 6018 | 5973 | 2036 | 3959 | 8054 | 1945 | 4073 | 3 9932 | 3.0091 | 53 0 |
| 15 | 7960 | 6053 | 5920 | 2106 | 3880 | 8159 | 1840 | 4212 | 9800 | 0265 | 45 |
| 30 | 7934 | 6088 | 5867 | 2175 | 3801 | 8263 | 1734 | 4350 | 9668 | 0438 | 30 |
| 45 | 0.7907 | 0.6122 | 1.5814 | 1.2244 | 2.3721 | 1.8367 | 3.1628 | 2.4489 | 3.9534 | 3.0611 | 15 |
| 38 0 | 7880 | 6157 | 5760 | 2313 | 3640 | 8470 | 1520 | 4626 | 9400 | 0783 | 52 0 |
| 15 | 7853 | 6191 | 5706 | 2382 | 3560 | 8573 | 1413 | 4764 | 9266 | 0955 | 45 |
| 30 | 7826 | 6225 | 5652 | 2450 | 3478 | 8675 | 1304 | 4901 | 9130 | 1126 | 30 |
| 45 | 7799 | 6259 | 5598 | 2518 | 3397 | 8778 | 1195 | 5037 | 8994 | 1296 | 15 |
| 39 0 | 7771 | 6293 | 5543 | 2586 | 3314 | 8880 | 1086 | 5173 | 8857 | 1466 | 51 0 |
| 15 | 7744 | 6327 | 5488 | 2654 | 3232 | 8981 | 0976 | 5308 | 8720 | 1635 | 45 |
| 30 | 7716 | 6361 | 5432 | 2722 | 3149 | 9082 | 0865 | 5443 | 8581 | 1804 | 30 |
| 45 | 7688 | 6394 | 5377 | 2789 | 3065 | 9183 | 0754 | 5578 | 8442 | 1972 | 15 |
| 40 0 | 7660 | 6428 | 5321 | 2856 | 2981 | 9284 | 0642 | 5712 | 8302 | 2139 | 50 0 |
| 15 | 0.7632 | 0.6461 | 1.5265 | 1.2922 | 2.2897 | 1.9384 | 3.0529 | 2.5845 | 3.8162 | 3.2306 | 45 |
| 30 | 7604 | 6494 | 5208 | 2989 | 2812 | 9483 | 0416 | 5978 | 8020 | 2472 | 30 |
| 45 | 7576 | 6528 | 5151 | 3055 | 2727 | 9583 | 0303 | 6110 | 7878 | 2638 | 15 |
| 41 0 | 7547 | 6561 | 5094 | 3121 | 2641 | 9682 | 0188 | 6242 | 7 35 | 2803 | 49 0 |
| 15 | 7518 | 6593 | 5037 | 3187 | 2555 | 9780 | 0074 | 6374 | 7592 | 2967 | 45 |
| 30 | 7490 | 6626 | 4979 | 3252 | 2469 | 9879 | 2.9958 | 6505 | 7448 | 3131 | 30 |
| 45 | 7461 | 6659 | 4921 | 3318 | 2382 | 9976 | 9842 | 6635 | 7303 | 3294 | 15 |
| 42 0 | 7431 | 6691 | 4863 | 3383 | 2294 | 2.0074 | 9726 | 6765 | 7157 | 3457 | 48 0 |
| 15 | 7402 | 6724 | 4804 | 3447 | 2207 | 0171 | 9609 | 6895 | 7011 | 3618 | 45 |
| 30 | 7373 | 6756 | 4746 | 3512 | 2118 | 0268 | 9491 | 7024 | 6864 | 3780 | 30 |
| 45 | 0.7343 | 0.6788 | 1.4686 | 1.3576 | 2.2030 | 2.0364 | 2.9373 | 2.7152 | 3.6716 | 3.3940 | 15 |
| 43 0 | 7314 | 6820 | 4627 | 3640 | 1941 | 0460 | 9254 | 7280 | 6568 | 4100 | 47 0 |
| 15 | 7284 | 6852 | 4567 | 3704 | 1851 | 055 | 9135 | 7407 | 6419 | 4259 | 45 |
| 30 | 7254 | 6884 | 4507 | 3767 | 1761 | 0651 | 9015 | 7534 | 6269 | 4418 | 30 |
| 45 | 7224 | 6915 | 4447 | 3830 | 1671 | 0745 | 8895 | 7661 | 6118 | 4576 | 15 |
| 44 0 | 7193 | 6947 | 4387 | 3893 | 1580 | 0840 | 8774 | 7786 | 5967 | 4733 | 46 0 |
| 15 | 7163 | 6978 | 4326 | 3956 | 1489 | 0934 | 8652 | 7912 | 5815 | 4890 | 45 |
| 30 | 7133 | 7009 | 4265 | 4018 | 1398 | 1027 | 8530 | 8036 | 5663 | 5045 | 30 |
| 45 | 7102 | 7040 | 4204 | 4080 | 1306 | 1120 | 8407 | 8161 | 5509 | 5201 | 15 |
| 45 0 | 7071 | 7071 | 4142 | 4142 | 1213 | 1213 | 8284 | 8284 | 5355 | 5355 | 45 0 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Course |
| | Dist. 1. | | Dist. 2. | | Dist. 3. | | Dist. 4. | | Dist. 5. | | |

| Course | Dist. 6. | | Dist. 7. | | Dist. 8. | | Dist. 9. | | Dist. 10. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | |
| ° ′ | | | | | | | | | | | ° |
| 30 15 | 5.1830 | 3.0226 | 6.0468 | 3.5264 | 6.9107 | 4.0302 | 7.7745 | 4.5340 | 8.6384 | 5.0377 | 59 45 |
| 30 | 1698 | 0452 | 0314 | 5528 | 8930 | 0603 | 7547 | 5678 | 6163 | 0754 | 30 |
| 45 | 1564 | 0678 | 0158 | 5791 | 8753 | 0903 | 7347 | 6016 | 5941 | 1129 | 15 |
| 31 0 | 1430 | 0902 | 0002 | 6053 | 8573 | 1203 | 7145 | 6353 | 5717 | 1504 | 59 0 |
| 15 | 1295 | 1126 | 5.9844 | 6314 | 8393 | 1502 | 6942 | 6690 | 5491 | 1877 | 45 |
| 30 | 1158 | 1350 | 9685 | 6575 | 8211 | 1800 | 6738 | 7025 | 5264 | 2250 | 30 |
| 45 | 1021 | 1573 | 9525 | 6835 | 8028 | 2097 | 6532 | 7359 | 5035 | 2621 | 15 |
| 32 0 | 0883 | 1795 | 9363 | 7094 | 7844 | 2394 | 6324 | 7693 | 4805 | 2992 | 58 0 |
| 15 | 0744 | 2017 | 9201 | 7353 | 7658 | 2689 | 6116 | 8025 | 4573 | 3361 | 45 |
| 30 | 0603 | 2238 | 9037 | 7611 | 7471 | 2984 | 5905 | 8357 | 4339 | 3730 | 30 |
| 45 | 5.0162 | 3.2458 | 5.8873 | 3.7868 | 6.7282 | 4.3278 | 7.5694 | 4.8688 | 8.4104 | 5.4097 | 15 |
| 33 0 | 0320 | 2678 | 8707 | 8125 | 7094 | 3571 | 5480 | 9018 | 3867 | 4464 | 57 0 |
| 15 | 0177 | 2898 | 8540 | 8381 | 6903 | 3863 | 5266 | 9346 | 3629 | 4829 | 45 |
| 30 | 0033 | 3116 | 8372 | 8636 | 6711 | 4155 | 5050 | 9674 | 3389 | 5194 | 30 |
| 45 | 4.9888 | 3334 | 8203 | 8890 | 6518 | 4446 | 4832 | 5.0001 | 3147 | 5557 | 15 |
| 34 0 | 9742 | 3552 | 8033 | 9144 | 6323 | 4735 | 4613 | 0327 | 2904 | 5919 | 56 0 |
| 15 | 9595 | 3768 | 7861 | 9396 | 6127 | 5024 | 4393 | 0652 | 2659 | 6280 | 45 |
| 30 | 9448 | 3984 | 7689 | 9648 | 5930 | 5312 | 4171 | 0977 | 2413 | 6641 | 30 |
| 45 | 9299 | 4201 | 7515 | 9900 | 5732 | 5600 | 3948 | 1300 | 2165 | 7000 | 15 |
| 35 0 | 9149 | 4415 | 7341 | 4.0150 | 5532 | 5886 | 3724 | 1622 | 1915 | 7358 | 55 0 |
| 15 | 4.8998 | 3.4629 | 5.7165 | 4.0400 | 6.5331 | 4.6172 | 7.3498 | 5.1943 | 8.1664 | 5.7715 | 45 |
| 30 | 8847 | 4842 | 6988 | 0649 | 5129 | 6456 | 3270 | 2263 | 1412 | 8070 | 30 |
| 45 | 8694 | 5055 | 6810 | 0897 | 4926 | 6740 | 3042 | 2582 | 1157 | 8425 | 15 |
| 36 0 | 8541 | 5267 | 6631 | 1145 | 4721 | 7023 | 2812 | 2901 | 0902 | 8779 | 54 0 |
| 15 | 8387 | 5479 | 6451 | 1392 | 4516 | 7305 | 2580 | 3218 | 0644 | 9131 | 45 |
| 30 | 8231 | 5689 | 6270 | 1638 | 4309 | 7586 | 2347 | 3534 | 0386 | 9482 | 30 |
| 45 | 8075 | 5899 | 6088 | 1883 | 4100 | 7866 | 2113 | 3849 | 0125 | 9832 | 15 |
| 37 0 | 7918 | 6109 | 5904 | 2127 | 3891 | 8145 | 1877 | 4163 | 7.9864 | 6.0182 | 53 0 |
| 15 | 7760 | 6318 | 5720 | 2371 | 3680 | 8424 | 1640 | 4476 | 9600 | 0529 | 45 |
| 30 | 7601 | 6526 | 5535 | 2613 | 3468 | 8701 | 1402 | 4789 | 9335 | 0876 | 30 |
| 45 | 4.7441 | 3.6733 | 5.5348 | 4.2855 | 6.3255 | 4.8977 | 7.1162 | 5.5100 | 7.9069 | 6.1222 | 15 |
| 38 0 | 7281 | 6940 | 5161 | 3096 | 3041 | 9253 | 0921 | 5410 | 8801 | 1566 | 52 0 |
| 15 | 7119 | 7146 | 4972 | 3337 | 2825 | 9528 | 0675 | 5718 | 8532 | 19 9 | 45 |
| 30 | 6956 | 7351 | 4783 | 3576 | 2609 | 9801 | 0435 | 6026 | 8261 | 2251 | 30 |
| 45 | 6793 | 7555 | 4592 | 3815 | 2391 | 5.0074 | 0190 | 6333 | 7988 | 2592 | 15 |
| 39 0 | 6629 | 7759 | 4400 | 4052 | 2172 | 0346 | 6.9945 | 6639 | 7715 | 2932 | 51 0 |
| 15 | 6464 | 7962 | 4207 | 4289 | 1951 | 0616 | 9695 | 6943 | 7439 | 3271 | 45 |
| 30 | 6297 | 8165 | 4014 | 4525 | 1730 | 0886 | 9446 | 7247 | 7162 | 3608 | 30 |
| 45 | 6131 | 8366 | 3819 | 4761 | 1507 | 1155 | 9196 | 7550 | 6884 | 3944 | 15 |
| 40 0 | 5963 | 8567 | 3623 | 4995 | 1284 | 1423 | 8944 | 7851 | 6604 | 4279 | 50 0 |
| 15 | 4.5794 | 3.8767 | 5.3426 | 4.5229 | 6.1059 | 5.1690 | 6.8691 | 5.8151 | 7.6323 | 6.4612 | 45 |
| 30 | 5624 | 8967 | 3228 | 5461 | 0832 | 1956 | 8437 | 8450 | 6041 | 4945 | 30 |
| 45 | 5454 | 9166 | 3030 | 5693 | 0605 | 2221 | 8181 | 8748 | 5756 | 5276 | 15 |
| 41 0 | 5283 | 9364 | 2830 | 5924 | 0377 | 2485 | 7924 | 9045 | 5471 | 5606 | 49 0 |
| 15 | 5110 | 9561 | 2629 | 6154 | 0147 | 2748 | 7666 | 9341 | 5184 | 5935 | 45 |
| 30 | 4937 | 9757 | 2427 | 6383 | 5.9916 | 3010 | 7406 | 9636 | 4896 | 6262 | 30 |
| 45 | 4763 | 9953 | 2224 | 6612 | 9685 | 3271 | 7145 | 9929 | 4606 | 6588 | 15 |
| 42 0 | 4589 | 4.0148 | 2020 | 6839 | 9452 | 3530 | 6883 | 6.0222 | 4314 | 6913 | 48 0 |
| 15 | 4413 | 0342 | 1815 | 7066 | 9217 | 3789 | 6620 | 0518 | 4022 | 7237 | 45 |
| 30 | 4237 | 0535 | 1609 | 7291 | 8982 | 4047 | 6355 | 0803 | 3728 | 7559 | 30 |
| 45 | 4.4059 | 4.0728 | 5.1403 | 4.7516 | 5.8746 | 5.4304 | 6.6089 | 6.1092 | 7.3432 | 6.7880 | 15 |
| 43 0 | 3881 | 0920 | 1195 | 7740 | 8508 | 4560 | 5822 | 1380 | 8135 | 8200 | 47 0 |
| 15 | 3702 | 1111 | 0986 | 7963 | 8270 | 4815 | 5553 | 1666 | 2837 | 8518 | 45 |
| 30 | 3522 | 1301 | 0776 | 8185 | 8030 | 5068 | 5284 | 1952 | 2537 | 8835 | 30 |
| 45 | 3342 | 1491 | 0565 | 8406 | 7789 | 5321 | 5013 | 2236 | 2236 | 9151 | 15 |
| 44 0 | 3160 | 1680 | 0354 | 8626 | 7547 | 5573 | 4741 | 2519 | 1934 | 9466 | 46 0 |
| 15 | 2978 | 1867 | 0141 | 8845 | 7304 | 5823 | 4467 | 2801 | 1630 | 9779 | 45 |
| 30 | 2795 | 2055 | 4.9928 | 9064 | 7060 | 6073 | 4193 | 3082 | 1325 | 7.0091 | 30 |
| 45 | 2611 | 2241 | 9713 | 9281 | 6815 | 6321 | 3917 | 3361 | 1019 | 0401 | 15 |
| 45 0 | 2426 | 2426 | 9497 | 9497 | 6569 | 6569 | 3640 | 3640 | 0711 | 0711 | 45 0 |
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